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HERBERT F. SCHWARZ MEMORIAL VOLUME

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Devoted to Entomology in General



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THE HERBERT F. SCHWARZ MEMORIAL VOLUME

Many Society members, upon learning of the death of Herbert Schwarz, spontaneously suggested recognition of his devotion and services to the Society. The Executive Committee has agreed that a fitting tribute is the designation of a volume of our *Journal* as a memorial; this would acknowledge his keen interest in the *Journal* and his services on the Publication Committee for many years.

Professor Warwick E. Kerr of São Paulo, Brasil, a co-investigator of the Stingless Bees, and a representative of Mr. Schwarz's international circle of friends, is assisting with the editing of papers on the Meliponidae and contributions from South America.

Mr. John C. Pallister, a Society member and museum co-worker, prepared the biographical sketch of Mr. Schwarz which appeared in the December 1960 issue of our *Journal*. This volume opens with a reprint of a biographical sketch, originally prepared for another journal, by Doctor Willis J. Gertsch, also a Society member and museum co-worker. It is included to accent the life and personality of Herbert F. Schwarz to whose memory this 70th volume of the *Journal of the New York Entomological Society* is affectionately dedicated.

The Editors
and the
Publication Committee



HERBERT FERLANDO SCHWARZ

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HERBERT FERLANDO SCHWARZ 1883-1960

After a full life of service and devotion to family, friends and country, Herbert Schwarz died on October 2, 1960. He was one of those rare individuals whose high code of honor and genuine sincerity charmed all who met him. He left behind friends in numbers in all parts of the world who will long remember him for his kindness, generosity and graciousness. A man of exceeding modesty, he took pleasure in praising the deeds and works of others but never mentioned his own. A man of great patriotism and love of country, he served in the Field Artillery during the First World War. A dedicated scholar all his life, he applied his broad knowledge to several fields with outstanding success. He stood high in the esteem of scientific colleagues throughout the world and left as his monument papers on bees that will long remain definitive works on the group. To his closest friends Herbert Schwarz personified all that was fine and noble in man.

Herbert Schwarz was born on Fire Island, near Long Island, New York, on September 7, 1883, the son of Frederick A. O. Schwarz and Caroline Clausen Schwarz. His preparatory schooling was acquired at the Phillips Exeter Academy, from which he graduated in 1900. After four years of work at Harvard University, he received the Bachelor of Arts degree in 1904. His liberal education emphasized literature, writing and languages, and in 1905, after a year of graduate study he was awarded the Master of Arts degree in philosophy. Continuation of his schooling at Columbia University brought him another Master of Arts degree in Elizabethan literature in 1907. Among his later honors was election to Sigma Xi. As an undergraduate he developed a keen interest in natural history and anthropology, especially Indian lore, which was responsible for taking him into the Southwest in 1904 and 1905 for study of the aboriginal cultures of that area. Fascinated by the lives and myths of the Navajos and the Pueblo tribes, he brought together a large body of notes on these

peoples. One of his first published papers was concerned with the "Spider Myths of the American Indians" and brought to light many of the charming details of this Indian mythology.

Herbert Schwarz always identified himself with the metropolitan area and spoke in the manner of the cultured New Yorker. His father had come to this country from Herford in Germany and had established the F. A. O. Schwarz toy company on Fifth Avenue, which in its specialty has become one of the landmarks of the city. Herbert was associated with the business for over fifty-five years, as an officer of the corporation in its early days and as a director during the last twenty-seven years of his life. His proficiency in modern languages was undoubtedly aided by numerous travels to all parts of the world. He spoke and read German fluently and had an excellent knowledge of Spanish, French and other Romance languages which he continued to study most of his life.

Schwarz in 1910 married Dorothy Constable, who was his frequent companion on subsequent trips and maintained a close interest in all his activities. Their four daughters are: Mrs. Barbara French, Mrs. Eleanor Stock, Mrs. Dorothy Hines and Miss Marjorie Schwarz.

During the period from 1909 to 1919 Herbert Schwarz acted as head of the editorial department and member of the board of G. P. Putnam's Sons in New York City. With a command of word and phrase reserved only to the gifted, it was inevitable that Schwarz would shine in the editorial and publishing field. He wrote fluently with a bold, handsome script and was a voracious reader of good books. A grievous fault, or so he told me, was his addiction to polysyllabic words and a ready acceptance of repetition with eddying currents of thought to bring out finer flavors and more exact meanings in writings. His leanings toward anthropology and natural history qualified him for editorial participation in the Putnam Field Book series.

To Schwarz, as editorial and lay adviser, came a book which was to have strong influence in shaping his future life. This was the "Field Book of Insects" by Dr. Frank E. Lutz, then curator of insects of the American Museum of Natural History. This work was published in 1918 and still remains, after forty years, the outstanding field guide on insects for the amateur and general student. Lutz and the gentle, reserved Schwarz were about

the same age and they quickly became close personal friends. They were opposites in many ways, with Lutz a man of penetrating mind who loved nothing more than to shock friend and foe with piercing barbs. Lutz kindled in Schwarz his first interests in insects and, because of his own liking for the biology and physiology of the bees, directed Schwarz's attention to the study of these captivating social interests. On many occasions Herbert Schwarz expressed his great admiration for Frank E. Lutz and regarded him as his teacher and mentor.

Herbert Schwarz's career at the American Museum of Natural History began in a modest way in 1919 when he spent three months in Colorado as a volunteer assistant with Dr. Lutz on a field expedition from the Department of Entomology. It was on this or a similar trip that he first met T. D. A. Cockerell who further encouraged his interest in bees and with whom he shared a close friendship and engaged in voluminous correspondence until Cockerell's death. In 1921, Schwarz was appointed as Research Associate of the Department of Entomology and he retained this post until his death, on a nearly full time basis. His interest in the American Museum and its manifold activities was very great and he participated in many ways. Thus, from 1921 to 1925 he was editor of *Natural History* magazine, and, following the death of Dr. Lutz in 1943, Schwarz was appointed acting chairman of the Entomology Department of the Museum, and he gave unreservedly of his time during the war period.

Once he had succumbed to the lure of insects, Herbert Schwarz swiftly became a full-fledged entomologist and participated in many museum field trips to far places. On most of these he was accompanied by one or both of his closest personal friends, Frank E. Lutz and Irving Huntington, but other trips were taken alone. Some of the areas visited were: Colorado, 1919; southern Florida in 1923; the Brownsville region of Texas in 1925; Barro Colorado Island, Canal Zone, in 1930 and 1933; the Cauca Valley of Colombia, in 1935; central Mexico and Yucatan in 1946; and southern Mexico in 1947. In addition to these collecting and field study expeditions Schwarz visited museums and scientific institutions all over the world, often with his wife and members of the family.

During his life Schwarz was active in many organizations to which he gave generously of time and money. As a Harvard graduate with fondest memories of early school years, he main-

tained close ties with his university and its Museum of Comparative Zoology and served on many committees. He often entertained friends and visitors at the Harvard Club on West Forty-fourth Street in New York, where his geniality as host will always remain a bright spot in the memories of his guests. As a Corresponding Member of the American Entomological Society, Schwarz was personally well-known to the older group of its membership. To Mr. J. A. G. Rehn, he was a good friend and "one of nature's noblemen, beloved by all who knew him for his many kindnesses, his courtesy—things increasingly rare in this matter-of-fact world."

Local organizations claimed a large share of Schwarz's interest. In 1919 he joined the New York Entomological Society and maintained a constant interest until his death. Here he fraternized with such now departed or inactive entomological stalwarts as William T. Davis, John D. Sherman, Ernest Bell, Andrew Mutchler, Charles Leng, and Frank Watson. He served on many committees, on the Board, and as President of the New York Entomological Society in 1935. He was also active in the National Audubon Society and the New York Academy of Sciences. Of the latter he was a Fellow and Council member for many years and Editor of Publications from 1925 to 1936. Another of his great interests was the Explorers' Club which he joined in 1921 and to which he gave sterling service as a Director and on various committees for many years. He was also for many years a member of Squadron A, a local cavalry group, which had its headquarters in the Old Armory.

Many of Schwarz's early papers were published in Natural History magazine during his tenure as editor. The broad scope of his writing is reflected in such titles as "Floral Designs in Textiles," "Eclipses, as Interpreted by the American Aborigines," "Swinging a Net in Southern Florida" and what may well have been his first published writing, "Tobacco as a Cure for Ailments." Thereafter, most of his publications, totalling at least sixty, were scientific contributions dealing rather exclusively with the bees of two groups. Much of what is known on the megachilid bees of the subfamily Anthidiinae we owe to Schwarz whose series of basic papers is still the standard reference for the group. The stingless honeybees of the family Meliponidae (or Apidae) became Schwarz's special province and

made him known to entomologists throughout the world. His greatest work is a voluminous tome exceeding five hundred printed pages, profusely illustrated, and entitled "Stingless Bees (Meliponidae) of the Western Hemisphere," which was published as a Bulletin of the American Museum of Natural History. Almost one third of these pages are devoted to the biology and natural history of stingless bees of the entire world and the remainder assigned to the systematics of the principal genera of the New World. This work will long remain a personal monument to the untiring devotion of a fine man. In its size and scope we see so much of what we admired in the man; it is the fruit of a keen, inquiring mind delineated in a boundless wealth of expression, an enduring work on a group of insects which he grew to love.

WILLIS J. GERTSCH

UNDESCRIBED SPECIES OF CRANE-FLIES
FROM THE HIMALAYA MOUNTAINS
(DIPTERA: TIPULIDAE), VII *

BY CHARLES P. ALEXANDER

AMHERST, MASSACHUSETTS

RECEIVED FOR PUBLICATION OCTOBER 10, 1961

ABSTRACT

The following new species from Sikkim are defined: *Gonomyia (Protogonomyia) clista*; *G. (P.) acustylata*; *G. (P.) distifurca*; *G. (P.) megalomata*, and *G. (P.) thiorhopala*. An additional species, *G. (P.) khasiana* is from the Khasi Hills, Assam.

The preceding part under this general title was published in the *Journal of the New York Entomological Society*, 69: 121–130; 1961. Virtually all species here considered are from Sikkim where they were taken by Dr. Fernand Schmid in 1959. Schmid's great contributions to our knowledge of the insects of the Himalayas have been discussed in preceding parts of this series of papers and elsewhere. I am greatly indebted to him for the time and effort devoted to collecting these fragile flies. The types of the novelties are preserved in my personal collection.

***Gonomyia (Protogonomyia) clista* new species**

Size relatively large (wing 7 mm or more); general coloration black, the surface opaque by a sparse pruinosity, pronotum and mesonotal scutellum yellowed; legs dark brown or black; wings tinged with brown, *Sc* long, cell 1st *M₂* closed; male hypopygium with outer lobe of basistyle slightly produced, the margin serrulate; apex of inner dististyle bispinous, provided with abundant long yellow setae.

MALE Length about 6.8–7 mm.; wing 7–7.5 mm.; antenna about 2.7–2.9 mm.

FEMALE Length about 6.5–7.5 mm.; wing 7.3–8.8 mm.

Rostrum and palpi brownish black. Antennae black, relatively long in

* Contribution from the Entomological Laboratory, University of Massachusetts.

Editorial note:

Publication of this manuscript marks the fiftieth year that Doctor Charles P. Alexander's manuscripts have appeared in the *Journal of the New York Entomological Society*. We are proud of this long association and hereby extend our best wishes to Dr. Alexander—now and for the future.

both sexes; basal flagellar segments oval, beyond the second more elongate, the fifth and succeeding segments long-subcylindrical, with long conspicuous verticils. Head black, pruinose, more heavily so in front.

Pronotal scutum dull black, scutellum and pretergites light yellow, the latter interrupted by a lateral flange on margin of praescutum before suture. Mesonotum black, the surface opaque by a sparse gray pruinosity; scutal callosities and posterior border of scutellum yellow; postnotum dull black, the cephalic margin of pleurotergite yellowed. Pleura black, sparsely pruinose, the ventral pteropleurite and metapleura more or less yellowed, in cases conspicuously so; dorsopleural region light yellow. Halteres blackened. Legs with coxae dull black; trochanters brownish yellow; femora brownish black, posterior pair paler, dark brown, tips blackened; tibiae and tarsi black. Wings tinged with brown, stigma very faintly darker, ill-delimited; veins dark brown. Veins with long trichia almost back to arculus; Cu_1 with trichia only near outer end. Venation: Sc long, Sc_1 ending very shortly before level of fork of Rs , Sc_1 alone subequal to $m-cu$; vein R_s with outer half deflected caudad, cell R_s at margin wide, more than three times R_2 ; cell 1st M_2 closed, much shorter than any of the veins beyond it; $m-cu$ at or close to fork of M .

Abdomen brownish black. Male hypopygium large. Tergal plate small, posterior border emarginate. Basistyle with outer apical angle flattened, triangularly produced, inner margin serrulate. Outer dististyle a broad flattened yellow blade, dilated at base, apex broadly obtuse; intermediate style distinctive, enlarged at apex, produced into a short black spine and provided with abundant long yellow setae; inner margin at near two-thirds the length with a much larger curved arm that terminates in an acute blackened point, base of style with abundant short setae and setulae; inner style shortest, the dilated apex with relatively few short spinoid setae and two much longer ones. Aedeagus flattened, broad, the apical point acute.

HOLOTYPE, ♂, Dikchu, Sikkim, 2300 feet, May 9, 1959 (Schmid). Allotype, ♀, Manu, Sikkim, 4920 feet, May 10, 1959. Paratotype, 1 ♂; paratypes, 3 ♂♂ with the allotype; 1 ♂, Nampung, Sikkim, 3280 feet, May 8, 1959; 1 ♀, Mangang, Sikkim, 3600 feet, May 9, 1959; 1 ♀, Chateng, Sikkim, 8700 feet, May 22, 1959 (Schmid).

Gonomyia (Protogonomyia) clista is distinct from all known regional species of the subgenus by the closed cell 1st M_2 of the wings. The western Palaearctic *Gonomyia (Ellipteroides) alboscutellata* (v. Roser) similarly has the cell closed but is placed in a different subgenus because of the structure of the ovipositor which has normal elongate slender cerci.

Gonomyia (Protogonomyia) acustylata new species

Size relatively large (wing 6 mm. or more); general coloration of body and appendages black; wings strongly blackened, veins black; male hypo-

pygium with apical flange of outer lobe of basistyle extensive; arms of second dististyle relatively short; inner dististyle stout, terminating in an acute spine, surface of outer third with long stout setae.

MALE Length about 5–6 mm.; wing 6–7 mm.; antenna about 1.8–2.1 mm.

FEMALE Length about 5.5–6 mm.; wing 6.5–7 mm.

Rostrum, palpi and antennae black; flagellar segments oval, verticils of the more proximal segments long. Head dull black.

Thorax dull black, without distinct yellow or paler pattern. Halteres blackened. Legs uniformly black. Wings strongly suffused with black; veins black. Venation: Sc long, Sc , ending nearly opposite fork of Rs ; cell $2nd\ M_2$ deep, about four to five times its petiole.

Abdomen, including genitalia of both sexes, black. Male hypopygium with apical glabrous flange of outer lobe of basistyle very extensive. Three dististyles; outer style slender, sinuous, gradually narrowed to a small obtuse head; second style with arms short, the longer one a slender straight rod, its stem with abundant setae; inner style distinctive, stout, narrowed outwardly into a spine, surface of outer third with abundant long stout setae. Aedeagus with numerous long pale setae.

HOLOTYPE, ♂, Tung, Sikkim, 4500 feet, August 2, 1959 (Schmid). Allotype, ♀. Paratotypes, 4 ♂♀; paratypes, several ♂♀, Chumtang, Sikkim, 5120 feet, July 18, 1959; ♂♀, Bop, Sikkim, 5950 feet, July 15, 1959 (Schmid).

The present fly is best distinguished from other regional members of the subgenus by the structure of the male hypopygium, particularly the distinctive inner dististyle. The identities of certain Indian species in this group described by Brunetti remain in question. In 1912 he described *nigripes* in *Mesocyphona*, and *nigra* in *Gnophomyia*; in 1918, *gracilis* in *Mesocyphona*, *incompleta* in *Limnophila*. The types of all of these are females, although some were indicated as being males. The names *gracilis* and *incompleta* are invalidated by prior use in the genus *Gonomyia*; of the remaining species, *nigra* seems to be separable by the short Sc , in this regard coming closer to still other species known from the western Himalayas. The last name, *nigripes*, pertains to a species that still remains in doubt but may well be found to refer to some one or another of various later defined species in this region. The present fly differs from Brunetti's description of *nigripes* in the lack of any yellow color on the body and in the more blackened wings. Bagchi's figure of one of the types of *nigripes* shows Sc somewhat shorter than is the case in the present fly, ending at near three-fourths the length of Rs .

Gonomyia (Protogonomyia) distifurca new species

Size above medium (wing of male 6.5 mm.); general coloration dull black, mesonotal scutellum obscure testaceous yellow; legs black; wings slightly darkened, Sc long; male hypopygium with outer lobe of basistyle relatively stout, without a flange; intermediate style very long and slender, setiferous, shallowly forked at tip; inner style broad, narrowed to a point, with a concentration of spinoid setae near tip.

MALE Length about 5.8 mm.; wing 6.5 mm.; antenna about 1.5 mm.

FEMALE Length about 5 mm.; wing 6.5 mm.

Rostrum brown, darker outwardly; palpi black. Antennae black; flagellar segments subcylindrical, a trifle shorter than the verticils. Head plumbeous, paler behind the antennae.

Pronotum plumbeous, anterior pretergites and sides of scutellum obscure yellow. Mesonotum chiefly blackened, sparsely pruinose; posterior border of scutellum obscure testaceous yellow. Pleura variegated dull black and obscure yellow, the darkest color on propleura, anepisternum, ventral sternopleurite and anterior pteropleurite, obscure yellow on pleurotergite, posterior pteropleurite and metapleura; dorsopleural and propleural membrane yellowed. Halteres brown, restrictedly more brightened at base, knob brownish black. Legs with coxae brownish black; trochanters paler, especially beneath; remainder of legs black, femoral bases restrictedly obscure yellow. Wings slightly darkened, not as conspicuously so as in some related species; stigma darker, long and inconspicuous; veins brown, paler in the prearcular region. Longitudinal veins with conspicuous macrotrichia, extending basad to arculus or even more basally on veins R and 1st A . Venation: Sc long, Sc_1 ending about opposite fork of Rs ; petiole of cell 2nd M_2 short, a little longer than $m-cu$, the latter at fork of M .

Abdomen brownish black, the hypopygial appendages paler. Male hypopygium with outer lobe of basistyle relatively stout, with long setae but without a modified flange. Outer dististyle straight, tip slightly dilated; intermediate style very long and slender, bent at near two-thirds the length, shallowly forked at tip, mesal face of stem with an extended series of long setae; inner style subequal in length to the intermediate one, much broader, especially at about one-third the length, thence gradually narrowed to the acute tip, with a dense grouping of about a dozen spinoid setae at and near tip, with more normal setae at near midlength. Aedeagus expanded before the strongly curved tip, before apex with numerous long setae.

HOLOTYPE, ♂, Dikchu, Sikkim, 2300 feet, May 9, 1959 (Schmid). Allotype, ♀, pinned with type. Paratypes, 2 ♂♂, Mangang, Sikkim, 3600 feet, May 9, 1959 (Schmid).

Gonomyia (Protogonomyia) distifurca is readily told from other regional species by the structure of the male hypopygium, especially the intermediate and inner dististyles. The most similar species are *G. (P.) acustylata* new species and *G. (P.) nilgiriana* Alexander.

Gonomyia (Protogonomyia) khasiana new species

MALE Length about 5.5 mm.; wing 6.5 mm.

Characters generally as in *nigripes*, differing especially in the structure of the male hypopygium. Wings very faintly infuscated, much paler than in *nigripes*; veins pale. Male hypopygium with the glabrous apical flange of outer lobe of basistyle extensive. Outer dististyle with stem short, the head expanded, nearly as long; intermediate style with the slender branch short, less than twice the dilated inner arm; inner style distinctive, appearing as a stout nearly straight blade that is produced into a basal lobe, inner apical angle extended into a strong spine; remainder of apex obliquely truncated, with about four or five spinoid setae.

HOLOTYPE, ♂, Cherrapunji, Khasi Hills, Assam, 4000 feet, August 1935 (S. Sircar).

Among the numerous regional species of the subgenus the present fly requires comparison with *Gonomyia (Protogonomyia) nigripes* (Brunetti). What appears to represent the true *nigripes* is a very different fly, with the hypopygial structure quite distinct. In 1918 Brunetti described *G. (P.) gracilis* (as a *Mesocypphona*) from the Darrang District, Assam-Bhutan Frontier, considered by Edwards (1924) as perhaps being a synonym of *nigripes*. This now appears to represent a distinct species but the name is invalidated by the earlier use in the genus by Skuse, 1890.

Gonomyia (Protogonomyia) megalomata new species

Size large (wing 7.5 mm or more); coloration of body and appendages black; male hypopygium with the flange of outer lobe of basistyle very large and flattened, tip obtusely rounded; intermediate style very shallowly forked at tip, the outer part terminating in two black teeth; inner style broad, tip obliquely obtuse, setae small, restricted to the outer third.

MALE Length about 7-7.5 mm.; wing 7.5-8.5 mm.; antenna about 2 mm.

FEMALE Length about 6.8-7 mm.; wing 8-8.5 mm.

Rostrum, palpi and antennae black; basal flagellar segments oval, the outer ones becoming long and slender. Head black.

Thorax black, the surface dull, especially the more pruinose pleura. Halteres and legs black. Wings tinged with blackish; stigmal region narrow, slightly darker than the ground; veins black.

Abdomen black, including the genitalia of both sexes. Ovipositor with cerci very small, as in the subgenus. Male hypopygium with the flange of outer lobe of basistyle very large and flattened, apex obtusely rounded, setae of lobe relatively small and weak, the longest less than twice the flange. Outer dististyle slender, straight, very slightly dilated outwardly, tip obtuse, base irregularly enlarged; intermediate style terminating in a compact black head, very shallowly bifid, the outer part terminating in two short

teeth, inner arm truncate, inner margin of stem beyond midlength produced into a setiferous cushion; inner style broad, with the usual basal extension, tip obliquely obtuse, setae numerous but very small and weak, restricted to outer third of style. Aedeagus with abundant setae, apex curved into a hook.

HOLOTYPE, ♂, Dikchu, Sikkim, 2300 feet, May 9, 1959 (Schmid). Allotopotype, ♀, pinned with type. Paratopotypes, 6 ♂♀; paratypes, ♂♀, Mangalbarey, Sikkim, 2800 feet, April 30, 1959; ♂♀, Mangang, Sikkim, 3600 feet, May 9, 1959; 1 ♀, Manu, Sikkim, 4920 feet, May 10, 1959; ♂, Nampung, Sikkim, 3280 feet, May 8, 1959; ♂, Teng, Sikkim, 4600 feet, May 12, 1959 (Schmid).

Gonomyia (Protogonomyia) megalomata is readily distinguished from other regional species by the hypopygial structure, especially the nature of the flange of outer lobe of basistyle and all three dististyles, particularly the intermediate style.

***Gonomyia (Protogonomyia) thiorhopala* new species**

Size medium (wing of male 6.3 mm.); general coloration dull black, pronotum, dorsopleural region and areas on the pleura yellow; knobs of halteres light sulphur yellow; legs black; wings very weakly darkened, stigma oval, dark brown; macrotrichia lacking on veins *Sc* or *Cu₁*; *Sc* ending about opposite two-thirds *Rs*; male hypopygium with the outer dististyle terminating in a flattened cultrate blade; intermediate style with the longer outer arm very slender, inner arm suboval, pointed at tip, surface with abundant setae; tip of aedeagus not decurved.

MALE Length about 5.5–5.6 mm.; wing 6.3–6.4 mm.; antenna about 1.6 mm.

Rostrum and palpi black. Antennae black; flagellar segments oval, subequal to the longest verticils. Head black, sparsely pruinose to appear plumbeous.

Pronotum dull black, pruinose, sides of scutellum, the pretergites, dorso-pleural membrane and an area behind the propleura light yellow. Mesonotum black, surface subnitidous, more heavily pruinose on sides; pseudosutural foveae black. Pleura black, sparsely pruinose, the membrane in the meral and metapleural regions yellow. Halteres with stem dusky, knob light yellow, very conspicuous. Legs with coxae plumbeous; remainder of legs black; femoral vestiture appressed, inconspicuous. Wings very weakly darkened, stigma oval, dark brown; veins brown. Several veins beyond cord with macrotrichia, lacking on distal section of *Cu₁*, very few on *R₂₊₃₊₄*; basad of cord without trichia on *Sc* or *Cu₁*, virtually lacking on 1st *A*, a few on outer half or less of *M* and 2nd *A*. Venation: *Sc* of moderate length, *Sc₁* ending about opposite two-thirds *Rs*, *Sc₂* at near one-thirds; a crossvein in cell *Sc* immediately above the arculus; veins *R₃* and *R₄* diverging outwardly, cell *R₂* at margin about one-third *R₃*; cell 2nd *M₂* nearly three times its petiole; *m-cu* about one-third its length beyond fork of *M*.

Abdomen black. Male hypopygium with outer lobe of basistyle only slightly produced, provided with long setae, apex subtruncate. Outer dististyle bent at a right angle at near midlength, the outer part a glabrous flattened cultrate blade, with a long carina on face at midwidth; intermediate style with the arms very dissimilar, the longer one dilated at base, gradually narrowed outwardly, the slender tip recurved, the shorter arm suboval, with abundant short setae, apex a short point; inner style generally similar in shape to the inner arm of the intermediate style, surface with recurved setae, tip broadly obtuse. Aedeagus with apex not decurved, as is the case in most other species of the subgenus.

HOLOTYPE, ♂, Singbeng, Sikkim, 4920 feet, April 26, 1959 (Schmid). Paratype, ♂, Gangtok, Sikkim, 5570 feet, May 3, 1959 (Schmid).

Gonomyia (Protogonomyia) thiorhopala is readily told from the other numerous regional species of the subgenus by the sulphur yellow knobs of the halteres, contrasting with the general dark coloration of the body.

OBSERVATIONS ON THE CLASSIFICATION OF THE BEES COMMONLY PLACED IN THE GENUS MEGACHILE (HYMENOPTERA: APOIDEA)¹

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ABSTRACT

The genus *Megachile* is divided into three genera, *Megachile*, *Chelicodoma*, and *Creightonella*, differing in their nesting habits as well as structure. The following subgenera are described: **Callomegachile**, **Chalicodomoides**, **Chelostomoda**, **Callochile**, *Chalicodoma* (*Callomegachile*) *mystaceana* is described from Australia; this species has usually been called *mystacea* Fabricius, a name properly used for *Megachile* (*Callochile*) *mystacea* Fabricius (= *M. ustulatiformis* Cockerell).

This paper consists of extracts from a large work which will soon be completed on the classification of the bees of Australia and neighboring regions. It is published here, separately, and in preliminary form, only because several of the names proposed are needed by persons working on the megachiline bees in America and Australia. Illustrations of the various groups occurring in the Australian region will be given in the work mentioned above. The bees concerned can be briefly characterized as the nonparasitic Megachilinae without distinct arolia.

Various authors have expressed the idea that *Megachile* (including *Chalicodoma*, *Gronoceras*, etc.) is a group of such diversity in structure and nesting habits that it ought to be divided, and in fact European authors for many years have separated their species of *Chalicodoma* as a distinct genus, which it certainly appears to be when only the European fauna is

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² I am indebted to Professor Jean Pasteels of Brussels, Belgium, for guidance in various ways. He and I had independently come to similar conclusions about the classification of *Megachile*-like bees, and we had independently coined the name *Callomegachile* for the same major group of Paleotropical species. He has been kind enough to urge me to publish this paper in spite of the fact that much of his work is already in manuscript form.

concerned. When faunas of other continents are examined, the gap between these *Chalicodoma* and *Megachile* is narrowed, so that the practice of naming some striking variants (e.g., *Thaumatosoma*, *Gronoceras*) and leaving the bulk of the species in *Megachile* has been followed in the African, Asiatic and Australian faunas. It seems that a more worth while procedure is to attempt major divisions.

A seemingly important biological division occurs between those which make nests with pieces of leaves or petals and those which use resin, mud, or other such material. It is not surprising that the mandibles of the female differ, those of the leafcutters having a sharp cutting edge in the interspace between the second and third teeth (second interspace) or in that between the third and fourth teeth (third interspace) or both. As such cutting edges are not found in other bees, their absence is presumably a primitive feature. Other common megachiline features, not shared by the leafcutters, exist among those which do not cut leaves. For example, the body is relative elongate and rather parallel-sided in those which do not cut leaves. This is true, also of some of the leafcutters, but the majority of them are broad, with the abdomen rather flattened. In the non-leafcutters, particularly the smaller ones, the posterior end of the scutellum is not strongly curved down but merely slopes, and the basal part of the propodeum is subhorizontal instead of subvertical. These statements apply to no leafcutters. Again the characteristics of the non-leafcutters are more like those of other megachilines and are presumably more primitive. Finally, the characters of the metanotum, axillar fossae and scutellar crests (terminology of Michener, 1944) as given in the key to genera, distinguish the two groups. It must be made clear that no one of these characters of the posterior end of the thorax, including those indicated in the key, holds perfectly; nonetheless, when one examines the posterior end of the thorax and considers the complex of features presented by it, one can tell whether to expect to find cutting edges on the mandibles of the female or not. There is an exception to the mandibular character in the subgenus *Chelostomoda*. Yet I think we are dealing with two natural groups whose distinctness is somewhat obscured by the amount of radiation that has occurred in each.

For the reasons outlined above it seems to me that it is practical and useful to distinguish two large groups in what has generally been called *Megachile*, and to use for these the names *Megachile* and *Chalicodoma*. Both of these genera are themselves diversified and worldwide in distribution (although *Chalicodoma* is represented, among the native species of the Western Hemisphere, by only two subgenera, *Chelostomoides* and *Stelodides*). An additional small group, *Creightonella*, seems worthy of generic rank.

Key to Genera

1. Mandible of female with cutting edge in second or third interspace between teeth, or both; metasoma usually broad, more or less flattened and not parallel-sided; metanotum fused to propodeum, sometimes indistinguishably so, although usually with a weak line separating them; sublaterally, metanotum usually considerably narrowed, often only half as long sublaterally as medially; axillar fossa shallow, surface behind it (scutellar crest) subhorizontal, no high crest between it and metanotum; eighth metasomal sternum of male bare, rarely with short discal hairs, without marginal hairs (except in *Creightonella*) 2
- Mandible of female without cutting edges between teeth (except in *Chelostomoda*, which has one in second interspace only); metasoma strongly convex dorsally, more or less parallel-sided; metanotum separated from propodeum by a suture which is often as conspicuous as scutellar-metanotal suture (except in the subgenus *Chalicodomoides*); sublaterally metanotum usually but little narrowed; axillar fossa deep, its posterior face usually ascending to strong scutellar crest between fossa and metanotum; eighth metasomal sternum of male with marginal hairs *Chalicodoma*
2. Male with six exposed sterna (sixth sometimes largely hidden); mandible of female with six teeth, second, third and fourth interspaces each with incomplete cutting edge, all of similar shape, that of fourth interspace small and inconspicuous from front; metasoma parallel-sided

Creightonella
- Male with four exposed sterna; mandibles of female with four or five teeth, cutting edges in second and third interspaces only, these edges usually of markedly different shapes or one of them absent; metasoma usually broad, not parallel-sided *Megachile*

Genus *Chalicodoma* Lepeletier

Chalicodoma Lepeletier, 1841, Histoire Naturelle des Insectes. Hyménoptères, 2: 309.

TYPE *Apis muraria* Fabricius, 1798 (designation of Girard, 1879, Traité Élementaire d'Entomologie, 2: 778).

This name is here used in a completely new sense to include

the species of *Megachile* s.l. that do not cut leaves (and possibly a few that do).

The following group names have been applied to forms falling in *Chalicodoma* as here defined: *Archimegachile* Alfken, 1933; *Chalicodoma* Lepeletier, 1841, s. str.; *Chelostomoides* Robertson, 1903 (= *Oligotropus* Robertson, 1903; *Gnathodon* Robertson, 1903; *Sarogaster* Robertson, 1918); *Digronoceras* Cockerell, 1931; *Gronoceras* Cockerell, 1907; *Hackeriapis* Cockerell, 1922; *Maximegachile* Guiglia and Pasteels, 1961; *Pseudomegachile* Friese, 1898; *Steloides* Moure, 1953, and *Thaumatosoma* Smith, 1865.

In addition to the groups listed above, several new groups are needed for Australian representatives of the genus, as indicated below. Except for the one new species, all *Chalicodoma* listed below are new combinations in that genus.

The type of *Chalicodoma* is commonly cited as *Apis muraria* Retzius, 1783. However, that name was not binomial; it was published as *Apis muraria nitida*. Hence it is not available as a name for the species nor for designation as the type species of *Chalicodoma*. Furthermore, *Apis muraria nitida* was probably not the species now known as *Chalicodoma muraria*, nor was it probably the same genus.

Fortunately, in designating the type species of *Chalicodoma*, Girard wrote "muraria Fabricius." Since Fabricius (1798) made no reference to Retzius' work or to any other work in which the species had been named, he obviously was describing the species as new. It is quite proper, therefore, to regard *Apis muraria* Fabricius as the type species of *Chalicodoma*, a course of action which maintains *Chalicodoma* in its usual sense.

This does not answer the question of the proper name for the species described as *Apis muraria* Fabricius, 1798. It is so well known that the name *muraria* probably should be conserved. It is probable that the oldest validly proposed name is *Apis caementaria* Meinecke, 1784. (A description of the work of an animal even though unaccompanied by a description of the animal itself, constitutes an indication in the sense of the rules of zoological nomenclature; Bull. Zool. Nomen., 4: 255, concl. 18, 1950.) Another available name is *Apis parietina* Fourcroy, 1785. It should be noted that this name antedates *Apis parietina* Fabricius, 1793, which is a well known European *Anthophora*.

Callomegachile new subgenus

TYPE *Chalicodoma mystaceana* Michener, new species

A large group of species of Paleotropical megachilids have the same large size, elongate bodies, and striking coloration that characterize *Creightonella*, *Gronoceras*, *Maximegachile*, and others. The species of this group, especially those having elongate, porrect mandibles and a short, tumescent clypeus in the female, have often been called *Eumegachile*. Examination of *Megachile bombycina* Radoszkowski, a Palearctic species on which *Eumegachile* was based, shows that while its mandibles are superficially like those of the tropical species usually placed in that subgenus, in reality the bee is very different. The mandibles of true *Eumegachile* are quadridentate with a cutting edge in the second interspace; like other leafcutting *Megachile* it has the rear part of the thorax similar to that of *Megachile* s.str., or in reality more like that of *Sayapis*, the metanotum and propodeum being less nearly vertical and the axillar fossae larger than in *Megachile* s.str. The tropical species, however, constitute a new subgenus of *Chalicodoma*, here named *Callomegachile*.

The subgenera *Pseudomegachile* and *Archimegachile* are in some ways similar but *Callomegachile* differs from them in its usually striking coloration and the lack of serration of the carina of the sixth tergum of the male. An interesting feature of *Callomegachile* is the arrangement of the punctures of the mesoscutum and the lower halves of the mesepisterna in irregular parallel rows so that a coarsely striate and occasionally extremely rugose appearance is produced. This character of punctuation, the slender male gonocoxites, and the rounded rather than bidentate sixth sternum of the female readily separate *Callomegachile* from *Maximegachile*.

Large or sometimes moderate sized, body parallel-sided; posterior part of thorax similar to that of *Chalicodoma* s.str.; head much developed posteriorly, often with a preoccipital carina or distinct ridge; prothoracic lobe usually carinate. Metasoma parallel-sided, occasionally (*mcnamerae*, etc.) with rather deep transverse grooves suggestive of *Chelostomoides* or *Hackeriapis*.

FEMALE Mandible broad, four or usually five toothed, or slender, porrect, three to four toothed, without cutting edge; clypeus not protuberant; first flagellar segment broader than long and shorter than second. Basitarsi much shorter and much narrower than corresponding tibiae; claws simple; sixth tergum slightly concave in profile, sides straight seen from above, surface with short suberect hairs and tomentum as are found on other terga;

sixth sternum with scopal hairs throughout, no bare rim; sterna without apical pubescent bands.

MALE Mandible tridentate with or without median inferior swelling or projection, basal projection absent; first flagellar segment broader than long, much shorter than second. First coxa with apical spine, sometimes reduced to tubercle or absent, anterior surface with short or long hairs, no rufsecent bristles; anterior tarsus not or slightly broadened; middle tibial spur present, claws symmetrical; middle and hind basitarsi unmodified, slender, middle ones more than half as long as tibia, hind ones about half as long as tibia. Carina of sixth tergum not much produced, a small weak emargination medially, a deep depression in tergum above center of carina, carina not toothed; margin of sixth tergum not toothed; four sterna exposed; hidden sterna delicate, often without modified hairs; gonocoxites very slender, apices simple.

This subgenus occurs in Africa, southern Asia, the Malay Archipelago, and Australia. It includes numerous species, many of which will be listed in the paper mentioned in the introduction. Among the included forms are not only the close relatives of the type species, such as *pretiosa* (Friese) and *nidulator* (Smith), but various somewhat smaller forms such as *cephalotes* (Smith) and *birói* (Friese), and a group of coarsely punctate forms [e.g., *faceta* (Bingham), *mcnamerae* (Cockerell)] in some of which the females have the scopal hairs thickened or spatulate.

The type species is described as new since, although it is one of the better known species of the subgenus, it is nameless, having long been misidentified as *Megachile mystacea* (Fabricius), which is in reality a species of the subgenus *Callochile* of *Megachile*.

Chalicodoma mystaceana new species

This species differs from its close relatives by the uniformly bright orange pubescence of the metasoma except for the base of the first tergum and by the entirely black thoracic pubescence. Relatives such as *C. pretiosa* and *nidulator* all have black and white areas, at least on the metasoma.

FEMALE Length 13 mm., wing length 9 mm.; Head broader than long; eyes scarcely diverging below; clypeus three times as broad as long, anterior margin little overhanging base of labrum, margin with two weak, feebly defined projections, one on each side of midline; interocellar distance equal to or slightly greater than ocellocular distance, about two thirds of ocellocipital distance; genal area broadest below, about as broad as eye seen from side, margined posteriorly by distinct preoccipital carina. Mandible five toothed, two upper teeth close together. Punctuation of head and thorax

dense; epistomal suture between tentorial pits and longitudinal median clypeal carina (strongest above) smooth and elevated; punctures of mesonotum arranged in irregularly transverse rows, those of lower half of mesepisternum in strong rows with distinct shining ridges between them; metanotum and propodeal triangle finely granular, upper margin of latter with zone of coarse shining pits, distinct laterally and almost absent medially; metasomal punctuation fine. Integument entirely black; wings fuscous. Pubescence of head and thorax black, whitish hair intermixed around antennal bases; pubescence of legs black, rufescent on tarsi, especially on under sides; metasoma with pubescence (including scopa) bright orange except that of first sternum and base of first tergum which is black; orange pubescence of terga largely obscuring surface, short and plumose, with scattered longer hairs.

MALE Length 10–11 mm., wing length 8 mm. Similar to female but eyes slightly converging below; clypeus little over twice as broad as long, anterior margin with weak median emargination. Mandible tridentate, lower surface with low, hairy prominence before middle. Anterior coxa with short, anteriorly directed apical spine, anterior surface of coxa with hairs short; anterior tarsus slightly broadened, second tarsal segment the broadest, almost twice as long as broad; first tarsal segment nearly as broad as second and nearly twice as long. Punctuation slightly coarser than in female, arrangement of thoracic punctures into rows less obvious but still distinct on lower half of mesepisternum; epistomal suture not elevated; clypeus without longitudinal carina. Integument black except for fore tarsus which is brown with outer margins of first four segments black; distal tarsal segments of other tarsi somewhat rufescent. Pubescence of head and thorax black, forming a dense white to ochre brush, mixed with sparse black hairs, across apex of clypeus; upper two thirds of clypeus nearly bare, with short, sparse black and white hairs; hairs between antennae dense and white; sides of face and vertex with white hairs intermixed among black; lower part of genal area with white hairs; hypostomal area and lower surface of mandible with dusky hairs; pronotal lobes with a few whitish hairs. Pubescence of legs black, dusky or rufescent in certain areas, strongly rufescent on tarsi, ochraceous on under sides of tarsi; front tarsus with some short glistening whitish hairs on outer surface, short coarse, robust, black hairs along inner margins of first three segments, and a few scattered, long, erect, robust, black hairs along outer margins of first three segments. Pubescence of metasomal terga like that of female, that of first and second sterna dusky, of third and fourth ochraceous.

HOLOTYPE female, allotype male, and one male and 19 female paratypes: Brisbane, Queensland, Australia, November 29, 1958, on flowers of *Pongamia pinnata* (C. D. Michener, collector). One female and three male paratypes, same locality, November 7, 1958 (C. D. Michener). The type and allotype will be placed in the collection of the Queensland Museum, Brisbane. Under the name *mystacea* (Fabricius), this species has been recorded from various localities in Queensland, north as far as Kuranda.

Chalicodomoides new subgenus
TYPE species *Megachile aethiops* Smith, 1853

This subgenus is known from a single species which was described as *aethiops* by Smith from Africa. It is, however, widely distributed in northern Australia whence it has been described under the names *doddiana* Cockerell and *clarki* Cockerell. It is presumably a native in Australia; it seems likely that the African record was an error. In general appearance and in the unusually oblique apical margin of the mandibles, this subgenus resembles a sparsely hairy *Chalicodoma* s. str. It differs from that subgenus as well as from most others in having only three exposed metasomal sterna in the male.

Large, with body parallel-sided; posterior part of thorax similar to that of *Chalicodoma* s. str.

FEMALE Mandible with apical margin very oblique, about half as long as maximum mandibular length with only three small widely separated teeth, no cutting edge; clypeus strongly produced over base of labrum; first flagellar segment as long as broad, shorter than second; small sharp tooth behind base of mandible. Basitarsi much shorter than and somewhat narrower than corresponding tibiae; claws each with strong basal tooth. Metasoma robust and rather parallel-sided; sixth tergum protruding midapically so that profile as well as lateral margins (seen from above) are concave; sixth sternum also produced midapically to form broad, weakly bilobed projection; scopal hairs present on base of sixth sternum, otherwise hairs confined to a large lateroapical fovea on each side; large triangular area between foveae and hairy base of sternum smooth and shining, this area continuous midapically with margin of apical projection which is also smooth and shining; sterna without apical hair bands.

MALE Mandible tridentate without inferior projection; first flagellar segment broader than long, shorter than second. Front coxa with anterior surface hairy, no apical spine or spicules; anterior tarsi slightly broadened; middle tibial spur present; middle and hind basitarsi slender, unmodified, much shorter than corresponding tibiae; middle claws symmetrical. Carina of sixth tergum moderately produced, a strong emargination in center, not toothed, no deep depression in tergum; margin of sixth tergum not toothed; three exposed sterna; fifth and sixth sterna with patches of modified hairs; gonocoxites with apices broad, hairy.

Chelostomoda new subgenus
TYPE *Megachile spissula parvula* Strand, 1913¹

This subgenus has exactly the appearance of small, rather ordinary species of *Hackeriapis* or *Chelostomoides*. *M. spissula*

¹ The trinomial is designated as the type because specimens of both sexes of that form have been available for study and dissection. Probably *parvula* is a synonym of *spissula*.

from Taiwan was placed in *Chelostomoides* by Mitchell (1937). This error is entirely understandable in view of the similarity to *Chelostomoides*. The subgenus differs especially by the characters in bold face in the description below, which also separate it from *Hackeriapis*. The presence of a cutting edge in the second interspace of the mandible of the female is unique in *Chalicodoma*; the only *Megachile* having only this cutting edge are in the subgenera *Sayapis* and *Eumegachile*.

Small, slender bodied, parallel-sided, coarsely sculptured; posterior part of thorax as well as transverse tergal grooves as in *Hackeriapis* and *Chelostomoides*, pitted zone at base of propodeum present only laterally; **tergal grooves not fasciate**; terga with apical pubescent fasciae; head not much developed posteriorly, lateral ocellus being little nearer eye than margin of vertex; preoccipital ridge sharp but not carinate; pronotal lobe carinate.

FEMALE Mandible five toothed, **large incomplete cutting edge in second interspace**; first flagellar segment broader than long, slightly shorter than second. Middle and hind basitarsi distinctly shorter and narrower than corresponding tibiae; claws simple. Metasoma parallel-sided, sixth tergum distinctly concave in profile apically, lateral margins about straight seen from above, surface with neither erect hair nor pale tomentum; sixth tergum with scopa over entire surface, **no shining marginal area**; sterna two to four with **apical hair bands** at least laterally.

MALE Mandible tridentate, no inferior projection; first flagellar segment slightly broader than long, less than half as long as second. First coxa hairy on anterior surface, without apical spine or reddish bristles; anterior tarsi somewhat broadened; middle tibial spur present, claws symmetrical; middle and hind basitarsi much less than half length of corresponding tibiae and narrower. Carina of sixth tergum rounded, not toothed, region of carina bulbous except medially, middle of carina minutely and weakly emarginate; margin of sixth tergum with a tooth at each side but no submedian teeth; three exposed sterna.

Distribution: India to Japan, Indonesia, New Guinea, and northern Australia.

The species of this subgenus will be listed in the work referred to in the introduction. Some of them are *spissula* (Cockerell), *erimae* (Mocsáry), and *carteri* (Cockerell).

Genus *Creightonella* Cockerell

Creightonella Cockerell, 1908, Entomologist, 41: 146.

TYPE *Megachile mitimia* Cockerell, 1908.

This group name has previously been used as an African subgenus of *Megachile*, for a group of species with the carina of the sixth tergum of the male very coarsely toothed. The carina is much more rounded in some of the Indomalayan species such as

frontalis (Fabricius). Species of this genus are large, parallel-sided forms, wholly black or with the abdomen covered with red hair or with patches of white hair laterally.

The most distinctive generic characters are the six-toothed mandibles of the female with similar shaped cutting edges in the second, third and fourth intervals (that in fourth small), the parallel-sided body with the posterior thoracic structure similar to that of *Megachile*, the six exposed metasomal sterna of the male (instead of three or four as in other genera), and the transverse form of the eighth metasomal sternum of the male (if the spiculum is ignored).

In the type species and certain other African forms the fourth sternum of the male is quadrispinose and the fifth, although exposed, is smooth, not sculptured like the preceding ones. In the Indomalayan species, as in some African ones such as *consanguinea* (Smith), the six exposed sterna are little modified and the first five are similarly punctate and hairy.

Very large, parallel-sided species; posterior part of thorax similar to that of *Megachile* s. str. but axillar fossa somewhat larger than usual in that group.

FEMALE Mandible six toothed with rather small, incomplete cutting edges in second, third and fourth intervals, that in fourth interval small and inconspicuous from the front; first flagellar segment shorter than second. Middle and hind basitarsi much shorter and narrower than corresponding tibiae; claws simple. Metasoma parallel-sided; sixth tergum scarcely concave in profile, without projecting apex, lateral margins nearly straight seen from above, surface with hairs longer than on preceding terga, no tomentum; sixth sternum with scopal hairs over almost entire surface, hiding posterior marginal bare zone; sterna without apical bands of pale hair.

MALE Mandible tridentate, lower margin with median projection, but lacking basal one; first flagellar segment much shorter than second. First coxa hairy anteriorly, with short, robust, blunt inner apical spine, without rufescent spicules; anterior tarsi unmodified or very slightly broadened; middle tibial spur present, claws symmetrical; middle and hind basitarsi less than half as long as corresponding tibiae and much slenderer. Carina of sixth tergum broadly expanded, slightly concave medially, slightly irregular to coarsely toothed, disc of tergum with longitudinal median ridge; posterior margin of sixth tergum with strong lateral tooth; seventh tergum with margin strongly convex, disc with strong longitudinal median ridge; six exposed sterna, sixth with posterior margin broadly convex and forming closure of genitoanal cavity, fifth and sixth sterna without membranous zones demarcating medasternites such as occur in most *Megachile* and *Chalicodoma*; eighth sternum a transverse plate, hairy at apex, with very long spiculum; gonocoxite very slender, not lobed apically.

Distribution: Africa to India, China, the Philippine Islands, Indonesia, and New Guinea, perhaps northern Australia.

Included species are listed in the work described in the introduction but include such forms as *frontalis* (Fabricius) [=*lachesis* (Smith)], *albifrons* (Smith), *fraterna* (Smith), *fervida* (Smith), *atrata* (Smith), etc.

Genus *Megachile* Latreille

Megachile Latreille, 1802, Histoire Naturelle de Fourmis, p. 413, 433.

TYPE *Apis centuncularis* Linnaeus, 1758 (designation of Curtis, 1828, British Entomology, 5: 218).

This generic name is here applied to all the broad-bodied leaf cutting groups. These include the subgenera *Acentron* Mitchell, 1934; *Amegachile* Friese, 1909; *Argyropile* Mitchell, 1934; *Austromegachile* Mitchell, 1943; *Chrysosarus* Mitchell, 1943; *Cressoniella* Mitchell, 1934; *Dactylomegachile* Mitchell, 1943; *Dasymegachile* Mitchell, 1943; *Delomegachile* Viereck, 1916; *Derotropis* Mitchell, 1936; *Eutricharaea* Thompson, 1872 (=*Paramegachile* Friese, 1899; *Androgynella* Cockerell, 1911); *Holcomegachile* Moure, 1953; *Leptorachis* Mitchell, 1934; *Litomegachile* Mitchell, 1934; *Macromegachile* Noskiewicz, 1948; *Megachile* Latreille, 1802, s. str. (=*Anthemois* Robertson, 1903; *Cyphopyga* Robertson, 1903); *Megachiloides* Mitchell, 1924; *Melanosarus* Mitchell, 1934; *Neomegachile* Mitchell, 1934; *Phaenosarus* Mitchell, 1934; *Pseudocentron* Mitchell, 1934; *Ptilosarus* Mitchell, 1943; *Tylomegachile* Moure, 1953; *Xanthosarus* Robertson, 1903; and *Xeromegachile* Mitchell, 1934.

In addition to the above listed subgenera, the genus *Megachile* includes certain parallel-sided forms which fall in the subgenera *Sayapis* Titus, 1905 (=*Gnathocera* Provancher, 1882; *Ceratias* Robertson, 1903) and *Eumegachile* Friese, 1898.

The following new subgenus is named at this time in order that placement of species can be made by certain other workers.

Callochile new subgenus

TYPE *Megachile ustulatiformis* Cockerell, 1910 (=*mystacea* Fabricius, 1775)

This is a subgenus containing large species of broad bodied *Megachile* in which the abdomen, instead of being provided with

apical bands of pale pubescence, has more or less extensive areas of orange tomentum. Superficially, therefore, if body shape (sometimes deceptive) is ignored, these species often resemble those of the subgenus *Callomegachile* of *Chalicodoma*. The terga have strong transverse postgradular grooves. The mandibles of the female are unusually broad, with the second and third teeth broad, thin, the third especially so, and truncate. The broad mandibles with long sharp edges are superficially suggestive of the African *Amegachile*, in which however, the sharp edges are distinctly extraordinarily well developed cutting edges, the teeth proper being pointed.

Large, broad-bodied species; posterior part of thorax as in *Megachile* s. str.

FEMALE Mandible quadridentate with long complete cutting edge in third interval, **third tooth irregularly and broadly truncate, second** (in our forms) **obliquely truncate**; first flagellar segment about two thirds as long as second; middle and hind basitarsi both distinctly shorter than respective tibia, hind nearly as broad as to broader than tibia; claws with small basal spicule. Metasoma broad, sixth tergum slightly concave in profile, lateral margin slightly concave seen from above, surface with suberect hairs and (like other parts of metasoma) orange tomentum; sterna without apical pubescent fasciae, the sixth without large hairless area but hairs short apically, no bare rim.

MALE Mandible four toothed, with inferior basal projection; first flagellar segment less than half length of second. First coxa with anterior face nearly bare, no rufescent bristles, apical spine large; anterior tarsus slightly enlarged; middle tibial spur present and movable; middle claws asymmetrical; middle and hind basitarsi about half lengths of respective tibiae. Carina of sixth tergum rounded with small median emargination; apical margin of sixth tergum with four small teeth, distance between submedian ones slightly greater than distance from one of them to lateral tooth; metasoma with four exposed sterna, fifth with short medasternal area provided with specialized capitate hairs; sixth not narrowed sublaterally, medasternal area represented by a shelf like expansion on either side from disc of sternum bearing coarse, immovable, capitate processes; eighth sternum without hairs on lateral margins; gonostylus somewhat enlarged and slightly lobed at apex.

Distribution: Northern Australia to southeast Asia and India.

Included species are listed in the work mentioned in the introduction. The following are two of the better known forms:

mystacea (Fabricius) (= *ustulatiformis* Cockerell, new synonymy)¹, *bicolor* (Fabricius).

Literature Cited

- FABRICIUS, JOH. CHRIST. 1798. Supplementum Entomologicae Systematicae, pp. 1-572 + 52, Hafnia.
- MICHENER, CHARLES D. 1944. Comparative external morphology, phylogeny, and a classification of the bees (Hymenoptera), Bull. Amer. Nat. Hist., 82: 151-326.
- MITCHELL, T. B. 1937. A revision of the genus *Megachile* in the Nearctic region, Part VIII, Trans. Amer. Ent. Soc., 63: 381-426.

¹ This is not the *mystacea* of most authors, which is *Chalicodoma* (*Callo-megachile*) *mystacea*. The type of *mystacea* in the Banks Collection, British Museum (Natural History) is a *Callockile* apparently identical to *ustulatiformis* which therefore falls in synonymy. To avoid confusion I have designated the latter name as the type of the subgenus.

FURTHER NOTES ON THE ETHOLOGY OF ASTATA (HYMENOPTERA: SPHECIDAE)

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RECEIVED FOR PUBLICATION DECEMBER 2, 1960

ABSTRACT

Notes are presented on the nesting behavior of *A. bicolor* Say and *A. leuthstromi* Ashmead. Two papers are added to the bibliography presented in review of the ethology of this genus published in the same Journal in 1957.

This paper is a supplement to observations on the nesting behavior of several species of the digger wasp genus *Astata* and a review of the ethology of the genus reported in the *Journal of the New York Entomological Society* (Evans, 1957).

As indicated in my earlier paper, one of the best sources of information on *Astata* is the excellent paper on *A. boops* (Schrank) by Tsuneki (1947). This is in Japanese with an English summary. Unfortunately, Tsuneki's paper was omitted from my bibliography and I wish to take this opportunity to correct this oversight. Powell and Burdick (1960) published a detailed account of a colony of *A. occidentalis* Cresson from Alameda County, California. Since this is a species studied by me in Indiana, their study provides an unusual opportunity for comparison of the behavior of two widely separated colonies of one species.

Astata bicolor Say On May 11, 1958 a single female of this species was found nesting on the beach of Laguna Madre, near Port Isabel, Cameron County, Texas. The soil consisted of hard-packed sand containing bits of shells and some organic matter. The nest was situated on the side of a slight elevation covered with halophytes. The entrance, surrounded by a rim of soil with a radius of 2 cm. and a height of 1 cm., was several centimeters from the nearest plants and not overhung by them. It was open most of the day, but at 4 P.M., a plug of soil about .5 cm. inside the entrance, closed it. I was busy with other digger wasps and did not actually see the wasp but marked the nest as that of an *Astata*. In the evening the nest was excavated and a female *A. bicolor* Say [det. K. V. Krombein] was found in the bottom of

the nearly vertical burrow at a depth of 10 cm. There were five fully provisioned cells, to the side of the burrow and separated from it and each other by 1-2 cm. of sand. They varied in depth from 7 to 10 cm. and each measured about 5×9 mm. As usual in this genus, the cells were smooth-walled and somewhat oblique. Two cells had six bugs and three had eight bugs; all bugs were similar and were small nymphs of an unrecognizable genus and species of the family Pentatomidae [det. H. Ruckes]. Four of the cells had an egg on the bottom bug in the usual manner of the genus. In the fifth cell there was an egg on the bug next to the bottom, the bottom bug being a minute nymph which was in the cell venter-up rather than venter-down as usual. All bugs appeared dead. Three of the eggs hatched in two days and the larvae (Evans, 1959) after five days of feeding were preserved.

This species has been studied briefly by the Peckhams (1898) in Wisconsin. They found it nesting in their garden, with the nest entrances overhung by vegetation as in *unicolor*. Because females of *unicolor* are sometimes "bicolored", that is, they have red abdomens, it is possible that the Peckham's had only *unicolor* in their garden but were applying the name *bicolor* to some of them.

Astata leuthstromi Ashmead Another female of this species was found nesting in my garden near Ithaca, New York on September 6, 1958 in almost the same place as the specimen found in 1956. The female descended to her nest with a stinkbug clasped beneath her in the usual manner of the genus, but I had disturbed the area and she was unable to find her nest. She left the area and returned several times, each time landing on the ground and dragging the bug about by its antennae. Finally she abandoned the bug and shortly thereafter found the open entrance to her nest. She entered the nest, emerged from it and after making a long orientation flight, flew away without trying to find the bug she had abandoned. This nest was observed periodically for several days but no change was noted and the female was not seen again. On September 14th the entrance was still open and I dug out the nest. The burrow was only 1.5 cm long and near the bottom of the burrow, at a depth of only 2 cm. were two cells, each oblique, smooth-walled and measuring about 6×10 cm. One cell had five bugs and a small larva was feeding on the bottom one in an inverted position. The other cell contained a pasty

mass of several bugs and a dead larva. The intact bugs were preserved and found to be early instar nymphs of *Acrosternum hilare* Say (Pentatomidae) [det. H. Ruckes].

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TSUNEKI, K. 1947. Nesting habits of *Astata boops* (Schrank) (Hymenoptera, Astatidae). *Mushi* 17: 103-111.

We note with regret the death of:

Johannsen, Oskar, who died on November 6, 1961 at the age of 91. Professor Johannsen, internationally known in entomological circles, was an authority on aquatic flies. He was a student of Professor John Henry Comstock and was author of several books and many articles on entomology.

Sutherland, Gordon, 50, of Glenn Ridge, New Jersey who served as economic entomologist for the Rockefeller Foundation and at the time of his death was manager of Cyanamid International's Agricultural Department.

A REMARKABLE NEW STENAMMA FROM COSTA
RICA, WITH PERTINENT FACTS ON OTHER
MEXICAN AND CENTRAL AMERICAN
SPECIES (HYMENOPTERA: FORMICIDAE)

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WASHINGTON, D. C.

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ABSTRACT

A new species, *expolitum* is described from Colombiana Farm, Santa Clara Province, Costa Rica from workers and a dealate female. In addition, the four other known species are briefly redescribed: *diversum* Mann of Honduras; *felixi* Mann of Mexico, Honduras and Costa Rica; *manni* Wheeler of Mexico; *schmidti* Menozzi of Costa Rica. A key is furnished for the identification of the workers of the five species.

The purpose of this paper is to describe an unusual species of *Stenamma* Westwood, and to present pertinent facts on known Mexican and Central American species of the genus. Other considerations that have led to the preparation of the paper are: (1) no inclusive paper has been published on the species that occur in Mexico and Central America; (2) types have been available to me of all but one of the species and (3) in the Amer. Midland Nat. 57(1): 133-174, illus. my revision of all the *Stenamma* of America, north of Mexico, was published. *Stenamma* have not been recorded from South America. The genus was thought to be entirely Holarctic in distribution until 1922 when Mann described two species, *diversum* and *felixi*, from the Neotropical Region. Mann found *diversum* such an atypical species of *Stenamma* that he commented at length on its peculiarity. At present five species are known from Mexico and Central America.

Stenamma diversum Mann

Stenamma diversum Mann, 1922, Proc. U. S. Natl. Mus. 61: 20-21, worker. Type loc.: Lombardia, Honduras; types in U. S. Natl. Mus. and Mus. Comp. Zool., Harvard Univ.

This species is well named and its peculiar habitus would certainly cause one to hesitate to assign the species to *Stenamma*.

Concerning this habitus, Mann remarked, "This species strikingly resembles some of the species of *Pristomyrmex* in its sculpture, it is like a small *Rogeria* in habitus and in having the inferior prothoracic corners angulate, but because of the 4 jointed antennal club and the structures of the head I have placed it in *Stenamma*, with doubt." Characters which especially distinguish the worker from workers of the typical species of *Stenamma* are: the short (2.25 mm.), stout body; the prominent subangular, thoracic humeri; angular inferior corners of the prothorax; posteriorly ascending base of the epinotum; the prominent pair of epinotal spines whose apices are directed dorsoposteriorly; the peculiar coarse, rugose-reticulate sculpture of the thorax; and the long, slender, apparently flexible body hairs. So far as I am aware the species is known only from the types. Mann's only remark concerning the ant's biology is that the species was "described from two workers collected beneath a stone."

Stenamma felixi Mann

Stenamma felixi Mann, 1922, Proc. U. S. Natl. Mus. 61: 21-23, fig. 10 (a, b), worker. Type loc.: San Juan Pueblo, Honduras; types in U. S. Natl. Mus. and Mus. Comp. Zool., Harvard Univ.

The worker of *felixi* is characterized by its large size (3.75 mm.), black or very dark brown body with lighter appendages, and its rather coarse sculpture. In addition to other sculpturing, the middle of the head and the dorsal surface of the anterior part of the thorax may be longitudinally rugulose, this being more distinct on the head than on the thorax. The epinotum appears transversely rugulose and the pronotal collar may be transversely rugulose in some individuals. The epinotum is unarmed and the petiolar node is high and distinctly subconical when viewed posteriorly. Mann's illustration of the worker is unusually good. Nothing is known about the biology of this species except the finding of specimens on orchid plants in quarantine. Apparently *felixi* is one of the common, if not the most common, species of *Stenamma* recorded in this paper.

In addition to the type locality the species has been collected from the following localities: *Mexico*, Jalapa, intercepted on orchid plants at Washington, D. C., July 8, 1914 by E. R. Sasseer.

—Costa Rica, Navarro Farm, March 1924, W. M. Mann; La Carpintera, April 1924, W. M. Mann, and Honduras, 1060 m., June 20, 1926, C. F. Nevermann.

Stenamma manni Wheeler

Stenamma manni Wheeler, 1914, Jour. N. Y. Ent. Soc. 22: 51, worker, alate female. Type loc.: on the trail between Real del Monte and El Chico, State of Hidalgo, Mexico, 10,000–11,000 ft.; types in U. S. Natl. Mus. and Mus. Comp. Zool., Harvard Univ.

I consider the original description of *manni* inadequate. The following characters of the worker of this species are based on my examination of type specimens. The worker is slender of form, 2.5–3.5 mm. in length, black in body color with the mandibles, clypeus and legs, especially the tibiae and tarsi, lighter. The sculpturing, although not coarse, is uniformly extended over the body except the gaster; the sculpturing consists largely of fine punctures interspersed among other sculpturing such as striae, rugulae, or reticulae according to the area of the body being examined; in some lights the sculpturing appears subopaque and with a grayish cast; in other lights the same sculpturing appears slightly shiny and lacking any grayish or other cast. The eye is about average size, 0.12 mm. in its greatest diameter, and contains about 9 or 10 ommatidia. The mesoepinotal impression is unusually broad and deep.

In addition to the type locality, the species has been collected by E. O. Wilson at Rancho Somecla, S. sl. P. Orizaba, Vera Cruz, Mexico, 3,700 m., Aug. 24, 1953, meadow, pine-oak cloud forest. Both workers and alate females were collected. According to Mann the type specimens were collected from two colonies "which were nesting under large stones in a damp spot in the pine forest."

Stenamma schmidti Menozzi

Stenamma schmidti Menozzi, 1931, Stettin Ent. Ztg. j. 92, h. 2, pps. 198–200, figs. 5, 6, worker, dealate female. Type loc.: Vara Blanca, 2000 m., Costa Rica; types in Deutsches Ent. Mus. and author's collection.—Menozzi, 1931, Boll. Lab. Zool. Portici 25: 267 (distribution, also remarks on type locality).—Borgmeier, 1937, Arch. Inst. Biol. Veg. (Rio de

Janeiro) 3: 232 (distribution, few notes on taxonomy of worker).

I have not seen the types but have studied two workers of this species in the U. S. Natl. Mus. that were collected at La Palma, Costa Rica, by Tristan and considered as *schmidti* by Menozzi. These specimens check with Menozzi's description. On the basis of the two workers the species may be characterized as follows: The worker is approximately 3 mm. in length, slender, with black body and lighter appendages. The body sculpturing is weak. The posterior border of the head and the pronotum are smooth and shiny, and the dorsum of the epinotum is finely and transversely rugulose. The eye is 0.13 mm. in its greatest diameter with 9 or 10 ommatida. The epinotum bears a pair of very small but distinct tubercles.

In addition to the type locality, *schmidti* has been collected from other localities in Costa Rica as follows: San Jose and La Palma, F. I. Tristan, dealate female and workers; and Hamburg Farm near San Jose, Feb. 24, 1929, F. Nevermann, dealate females and workers. Menozzi determined the individuals collected by Tristan at La Palma and San Jose, and Borgmeier determined the individuals collected by Nevermann at Hamburg Farm. Apparently nothing has been published on the biology of this species.

***Stenamma expolitum*, new species**

WORKER Length 3.7 mm. Head subrectangular, with moderately convex sides, rounded posterior corners and straight or almost imperceptibly emarginate posterior border; greatest length of head (excluding the mandibles) 0.85 mm., greatest width 0.75 mm. Mandible subtriangular, with 4 or 5 distinct apical teeth, the basal teeth vestigial or absent. Antenna 12-segmented, apex of scape attaining the posterior border of the head, last 4 segments of the funiculus noticeably enlarged, the combined lengths of these segments exceeding the length of the remainder of the funiculus. Clypeus with a pair of weak longitudinal carinae between which there is a shallow groove leading to the emargination at the middle of the anterior border of the clypeus. Greatest diameter of the eye is approximately 0.13 mm. with 7 or 8 ommatidia. In profile, the outline of the promesonotum forms a strong and rather even convexity. Mesoepinotal impression well-developed, broad and rather deep. Base of epinotum weakly convex, meeting the declivity in a scarcely perceptible angle. The junction of these two surfaces bears no spines or tubercles. From above, the promesonotum appears compressed on each side and forms dorsally distinct but rather rounded humeri. Legs

moderately long and slender but with somewhat incrassated femora and tibiae. Petiole, from above, with a slender elongate pedicel and a node that when viewed posteriorly is slender, subconical. Postpetiolar node larger than the node of the petiole, longer than wide, subpyriform, narrowest anteriorly. Gaster oblong, without basal humeri, the first segment occupying much of the dorsal surface of the gaster.

Body almost entirely smooth and shiny with the following exceptions: Some fine longitudinal striae on the front of the head and some fine longitudinal rugulae on the cheeks, dorsal surface of head with fine, scattered hair-bearing punctures; metapleura irregularly sculptured, the thorax with weak sculpture in the sutures and fairly coarse transverse rugulae on the dorsal surface of the epinotum.

Hair grayish or yellowish depending upon the light, moderately abundant, long, suberect to erect, shorter and more reclinate on the scapes and legs.

Body black or very dark brown with lighter appendages and apex of gaster.

DEALATE female Length 4.6 mm. Slightly larger than the worker, with the thorax especially stouter. Head larger and proportionally broader, the greatest length (excluding the mandibles) 0.9 mm., greatest breadth 0.83 mm. Ocelli extremely small and pale. Eye larger, 0.2 mm. in its greatest diameter and containing 14 or 15 ommatidia. Base of epinotum longer than the declivity and meeting the latter at an angle, no spines or tubercles at the junction of these areas. Sculpture of the body, especially on the dorsum of the thorax, generally coarser and more extensive than that of the worker but with the pilosity and color similar.

Workers vary relatively little in size, the lengths ranging from 3.7 mm.-4.05 mm. The heads of some individuals are notably more slender than others. The basal mandibular teeth vary greatly in number, size, and placement. A striking difference also occurs in the degree of development of the mesoepinotal impression; it is broad and deep in some individuals and narrow and shallow in others.

The worker of *expolitum* is characterized by its almost smooth and shiny body; long scape, the apex of which attains the posterior border of the head; the rounded but distinct pronotal humeri; and the unarmed epinotum, the dorsal surface of which is transversely rugulose. I do not know of any species of *Stenamma* that is closely related to *expolitum*. The smooth, shiny surface of the body is unique and I have chosen to emphasize this peculiarity by naming the ant *Stenamma expolitum*.

The species has been described from the holotype, 12 paratype workers, and a dealate paratype female.

Type locality: Colombiana Farm, Santa Clara Province, Costa Rica, March-April 1924, W. M. Mann.

The types have been distributed as follows: The holotype, 7 paratype workers, and a dealate paratype female to the U. S. National Museum; 3 paratype workers to the Museum of Comparative Zoology, Harvard University; and 3 paratype workers to the American Museum of Natural History. All of these bear U. S. N. M. No. 65967.

The biology of *S. expolitum* is unknown.

Key for the Identification of the Workers of the
Species of *Stenamma* of Mexico and Central America

- | | |
|--|-------------------------|
| 1—Body smooth and shiny except for a few minor areas, (epinotum unarmed), Costa Rica— <i>expolitum</i> , n. sp. | |
| Body not as described above | 2 |
| 2—Epinotum armed | 3 |
| Epinotum unarmed, (epinotum, especially posteriorly, bearing transverse rugulae in addition to other sculpturing, petiolar node high, subconical when viewed posteriorly), Mexico, Honduras, Costa Rica— <i>felixi</i> Mann | |
| 3—Head mostly smooth and shiny, epinotum bearing a pair of well-developed, acutely tipped spines 0.2 mm. in length, (thorax coarsely rugulose-reticulate; body hairs rather abundant, long and slender, suberect to erect), Honduras— <i>diversum</i> Mann | |
| Head and thorax not as described above; epinotum bearing a pair of weakly developed or vestigial tuberclelike spines | 4 |
| 4—Pronotum and much of mesonotum smooth and shiny; epinotal tubercles very vestigial, Costa Rica | <i>schmidti</i> Menozzi |
| Pronotum and much of mesonotum with fine longitudinal rugulae and interrugal punctures, which give these regions a subopaque cast; epinotal tubercles small but not vestigial, Mexico— <i>manni</i> Wheeler | |

AN ANNOTATED LIST OF LYCAENIDAE (LEPIDOPTERA, RHOPALOCERA) OF THE WESTERN HEMISPHERE

by WILLIAM PHILLIPS COMSTOCK AND EDGAR IRVING HUNTINGTON

[Continued]

ocrisia Hewitson,, W. C., *Thecla*

Type Locality: Ecuador (type) and Mexico.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 5 (London).

Additional Reference: Hewitson, W. C., 1869 (April), Illus. of Diurnal Lepidoptera, vol. 1, p. 123, vol. 2, pl. 48, figs. 236 ♂, 235 ♀ (London).

Synonyms: *peruviana* Erschoff, *zora* Hewitson.

octomaculata Dean, F. Roy, *Chrysophanus hypophlaeas* var.

Type Locality: Meramac Highlands, Missouri, May 14, 1918.

Location of Type:

Original Description: 1918 (August), Lepidoptera, vol. 2, p. 60 (Forest Hills, Mass.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 26, no. 435 (Los Angeles, Calif.). (Places *octomaculata* as an aberration of *hypophlaeas* Boisduval.)

octoscripta Buchholz, Otto, *Mitoura gryneus*

Type Locality: Passaic County, New Jersey, April 28-May 14.

Location of Type: American Museum of Natural History.

Original Description: 1951 (June), Bull. Brooklyn Ent. Soc., vol. 46, p. 78 (Lancaster, Pa.).

odinus Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Volcán de Chiriquí, Panamá.

Location of Type: British Museum (Natural History).

Original Description: 1887 (September), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 70, vol. 3, pl. 56, figs. 20, 21 ♀ (London).

ohausi Spitz, Roberto, *Thecla*

Type Locality: São Paulo (São Caetano).

Location of Type: Museu Paulista, São Paulo.

Original Description: 1933, Revista de Entomologia, vol. 3, p. 224, fig. 1 (Rio de Janeiro).

okanagana McDunnough, James H., *Strymon saepium* var.

Type Locality: Peachland, British Columbia, July 5, 1907.

Location of Type: Canadian National Collection, Ottawa, Ontario, no. 5502 ♂.

Original Description: 1944 (September), Can. Ent., vol. 76, no. 9, p. 190 (Guelph, Ont.).

olbia Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 97, vol. 2, pl. 36, figs. 85 ♂, 86 ♀ (London).

Subspecies: *phallica* Hewitson.

oleris Druce, Hamilton H., *Thecla*

Type Locality: South Paraguay.

Location of Type: Godman Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 614, pl. 36, fig. 14 ♂ (London).

ontario Edwards, William H., *Thecla*

Type Locality: Port Stanley, Ontario, July, 1868.

Location of Type:

Original Description: 1868 (September), Trans. Amer. Ent. Soc., vol. 2, p. 209 (Philadelphia, Pa.).

opacitas Druce, Hamilton H., *Thecla*

Type Locality: Atoyac, Vera Cruz, Mexico., May.

Location of Type: Godman Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 624 (London).

opalia Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 6 (London).

Additional Reference: Hewitson, W. C., 1869 (April), Illus. of Diurnal Lepidoptera, vol. 1, p. 134, vol. 2, pl. 53, figs. 300, 301 ♂ (London).

ophelia Hewitson, W. C., *Treclla*

Type Locality: Amazon.

Location of Type: British Muscum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 110, vol. 2, pl. 46, figs. 209, 210 ♂ (London).

ophia Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 6, (London).

Additional Reference: Hewitson, W. C., 1873 (February), Illus. of Diurnal Lepidoptera, vol. 1, p. 149, vol. 2, pl. 59, figs. 379, 380 ♂, 381 ♀ (London). Amazon (Pará).

Synonyms: *ornea* Hewitson.

opisena Druce, Hamilton H., *Thecla*

Type Locality: Colombia.

Location of Type: Druce Collection (♂).

Original Description: 1912 (June), Ent. Mo. Mag., Series 2, vol. 23, p. 131, pl. X, fig. 3 ♂ (London).

oppia Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Cordova, Mexico.

Location of Type: British Museum (Natural History).

Original Description: 1887 (August), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 56, vol. 3, pl. 55, figs. 1, 2 ♂ (London).

optilete Knoch, August Wilhelm, *Papilio*

Type Locality: Europe.

Location of Type:

Original Description: 1781, Beitrage zur Insectengeschichte, vol. 1, p. 76, pl. 5, figs. 5, 6 (Leipzig).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 27, no. 454 (Los Angeles, Calif.). (Excludes *optilete optilete* Knoch from the American fauna; the subspecies *optilete yukona* Holland is the representative.)

Subspecies: *yukona*. Holland.

orasus Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Purula, Guatemala.

Location of Type: British Museum (Natural History).

Original Description: 1887 (August), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 59, vol. 3, pl. 55, figs. 11, 12 ♂ (London).

orbitulus Strecker, Herman, *Lycaena* (not dePrunner).

Type Locality:

Location of Type:

Original Description: 1874 (May), Lepidoptera, Rhopaloceres and Heteroceres, p. 86, pl. 10, fig. 16 (Reading, Pa.).

Note: Strecker misidentified *podarce* Felder as the European *orbitulus* dePrunner.

orcidia Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1874 (December), Illus. of Diurnal Lepidoptera, vol. 1, p. 183, vol. 2, pl. 73, figs. 560, 561 ♂ (London).

Additional Reference: Godman, F. D. and O. Salvin, 1887 (September), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 67, vol. 3, pl. 56, figs. 11, 12 ♂, 13 ♀ (London). (Chiriquí, Panamá). (This figure of the underside is different from Hewitson's).

orcilla Hewitson, W. C., *Thecla*

Type Locality: Ecuador.

Location of Type: British Museum (Natural History).

Original Description: 1874 (December), Illus. of Diurnal Lepidoptera, vol. 1, p. 184, vol. 2, pl. 73, figs. 564, 565 ♂, 566 ♀ (London).

orcillula Strand, Embrik, *Thecla*

Type Locality: Costa Rica (2 ♀).

Location of Type: Niepelt Collection.

Original Description: 1916 (December), Lepidoptera Niepeltiana, pt. 2, p. 17, pl. 15, fig. 3 (Berlin).

orcus Edwards, William H., *Lycaena*

Type Locality: California (1 ♂).

Location of Type:

Original Description: 1869 (September), Trans. Amer. Ent. Soc., vol. 2, p. 376 (Philadelphia, Pa.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 27, no. 457 (Los Angeles, Calif.). (Places *orcus* as an aberration of *pheras* Boisduval.)

orcynia Hewitson, W. C., *Thecla*

Type Locality: Guatemala (Polochic Valley).

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 11 (London).

Additional References: Hewitson, W. C., 1869 (April), Illus. of Diurnal Lepidoptera, vol. 1, p. 121, vol. 2, pl. 50, figs. 262, 264 ♂, 263, 265 ♀ (London). Godman, F. D. and O. Salvin, 1887 (September), Biologia Centrali-Americanana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 65 (London). (Say that species figured by Hewitson (figs. 263, 265 ♀) are not the females of *orcynia*.)

Synonyms: *aunia* Hewitson, *anina* Druce, *anthracia* Hewitson.

oreala Hewitson, W. C., *Thecla*

Type Locality: Bahia.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 27 (London).

Additional Reference: Hewitson, W. C., 1874 (December), Illus. of Diurnal Lepidoptera, vol. 1, p. 152, vol. 2, pl. 60, figs. 399, 400, 401 ♂, 402, 403 ♀ (London).

oregonensis Barnes, William and James H. McDunnough *Philotes battoides*
Type Locality: Crater Lake, Oregon, last two weeks in July.

Location of Type: United States National Museum (Barnes Collection).

Original Description: 1917 (March), Contributions to the natural history
of the Lepidoptera of North America, vol. 3, no. 4, p. 214, pl. 16, figs. 1-3
(Decatur, Illinois).

oreopola Hayward, Kenneth J., *Itylos*

Type Locality: Casa de Piedra del Río de la Puerta, Dept. de Tafí, Tucumán,
Argentina, 3600 meters, January, 1931.

Location of Type: Fundacion Miguel Lillo, Tucumán.

Original Description: 1949, Acta Zool. Lilloana, vol. 8, p. 580, pl., fig. 2
(Tucumán, Argentina).

orgia Hewitson, W. C., *Thecla*

Type Locality: Venezuela and Cayenne.

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 102,
vol. 2, pl. 41, figs. 148, 149 ♀, pl. 43, fig. 176 ♂ (London).

oribata Weymer, Gustav, *Thecla*

Type Locality: Tacora, Bolivia, 3600-4600 m.

Location of Type:

Original Description: 1890, in Reiss and Stubel, Reisen in Sud-Amerika,
p. 123, pl. 4, fig. — (Berlin).

Synonyms: *anosma* Draudt.

origo Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Chiriquí, Panamá, Amazon Valley (G. and S.).

Location of Type: Staudinger Collection.

Original Description: 1887 (September), Biologia Centrali-Americana,
Insecta Lepidoptera-Rhopalocera, vol. 2, p. 73, vol. 3, pl. 56, figs. 32, 33 ♂
(London).

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London,
p. 608 (London). (Makes *origo* a synonym of *partunda* Hewitson.)

Note: In 1941 Comstock and Huntington identified *origo* as species.

orios Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Panima, Guatemala.

Location of Type: British Museum (Natural History).

Original Description: 1887 (August), Biologia Centrali-Americana, In-
secta, Lepidoptera-Rhopalocera, vol. 2, p. 51, vol. 3, pl. 54, figs. 10, 11 ♂
(London).

ornatrix Druce, Hamilton H., *Thecla*

Type Locality: Río Demerara, British Guiana.

Location of Type: Druce Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 572, pl.
31, fig. 5 ♂ (London).

ornea Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 7 (London).

Additional Reference: Hewitson, W. C., 1873 (February), Illus. of Diurnal Lepidoptera, vol. 1, p. 149, vol. 2, pl. 59, fig. 381 ♀ (London). Amazon (Pará). (Synonym, female of *ophia* Hewitson).

oro Scudder, Samuel H., *Nomiades*

Type Locality: Colorado.

Location of Type:

Original Description: 1876 (February), Can. Ent., vol. 8, p. 23 (London, Ont.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 28, no. 473 (Los Angeles, Calif.). (Places *oro* as a subspecies of *lygdamus* Doubleday.)

orobia Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 103, vol. 2, pl. 40, figs. 134, 135 ♂ (London).

Additional Reference: Godman, F. D. and O. Salvin, 1887 (August), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 61, vol. 3, pl. 55, figs. 29, 30 ♂ (London). (Veraguas, Panamá.)

orobiana Hewitson, W. C., *Thecla*

Type Locality: Amazon (Ega).

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 103, vol. 2, pl. 46, figs. 205, 206 ♂ (London).

Synonyms: *cosmophila* Tessmann.

orocana Druce, Hamilton H., *Thecla*

Type Locality: El Porvenir, East Peru, 900 meters.

Location of Type: Druce Collection (♂).

Original Description: 1912 (June), Ent. Mo. Mag., Series 2, vol. 23, p. 130, pl. IX, fig. 11 ♂ (London).

orses Godman, F. D. and O. Salvin, *Thecla*

Type Locality: San Gerónimo, Guatemala.

Location of Type: British Museum (Natural History).

Original Deserption: 1887 (June), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 43, vol. 3, pl. 53, figs. 11, 12 ♂ (London).

orsina Hewitson, W. C., *Thecla*

Type Locality: Bolivia.

Location of Type: British Museum (Natural History).

Original Description: 1877 (January), Illus. of Diurnal Lepidoptera, vol. 1, p. 200, vol. 3, pl. 79, figs. 649, 650 ♀ (London).

ortaloides Lathy, Percy I., *Thecla*

Type Locality: Petropolis, Brazil, February 10, 1876.

Location of Type: Fournier Collection, Paris.

Original Description: 1930 (June), Trans. Ent. Soc. London, p. 135, pl. 9, fig. 12 ♂ (London).

ortalus Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Córdova, Mexico.

Location of Type: British Museum (Natural History).

Original Description: 1887 (August), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 52, vol. 3, pl. 54, figs. 14, 15 ♂ (London).

ortygnus Cramer, Pierre, *Papilio*

Type Locality: Surinam.

Location of Type:

Original Description: 1779, Papillons exotiques des trois parties du monde, vol. 3, p. 84, pl. 243, fig. B (Amsterdam).

Additional Reference: Godman, F. D. and O. Salvin, 1887 (June), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 41, vol. 3, pl. 53, figs. 1, 2 ♂ (London).

Subspecies: *lauta* Draudt.

oslari Dyar, Harrison G., *Thecla*

Type Locality: Tucson, Arizona.

Location of Type: United States National Museum, no. 7726. (Cotype in the American Museum of Natural History).

Original Description: 1904 (March), Jour. New York Ent. Soc., vol. 12, p. 40 (Lancaster, Pa.).

Additional Reference: Stallings, D. B. and J. R. Turner, 1947 (February), Ent. News, vol. 58, p. 40 (Philadelphia, Pa.). (Place *oslari* as a subspecies of *alcestis* Edwards.)

ostia Hewiston, W. C., *Thecla*

Type Locality: Rio de Janeiro.

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 110, vol. 2, pl. 40, figs. 130, 131 ♂ (London).

ostrinus Druce, Hamilton H., *Thecla*

Type Locality: Cayenne, French Guiana.

Location of Type: Godman Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 596, pl. 35, fig. 6 ♂ (London).

Additional Reference: Schaus, William, 1920, Ent. News, vol. 31, p. 176 (Philadelphia, Pa.). (Makes *ostrinus* a synonym of *bianca* Möschler.)

otoheba Dyar, Harrison G., *Thecla*

Type Locality: Dominica, B. W. I., June-July, 1913.

Location of Type: United States National Museum, no. 18,055.

Original Description: 1915, Proc. U. S. Natl. Mus., vol. 47, p. 423 (Washington, D. C.).

Additional Reference: Comstock, W. P. and E. I. Huntington, 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 76 (New York). (Place *otoheba* as a synonym of *dominicana* Lathy.)

oxida Hewitson, W. C., *Thecla*

Type Locality: Jorge, Ecuador.

Location of Type: British Museum (Natural History).

Original Description: 1870 (March), Equatorial Lepidoptera, Buckley, p. 68 (London).

Additional Reference: Hewitson, W. C., 1878 (November), Illus. of Diurnal Lepidoptera, vol. 1, p. 212, vol. 2, pl. 85, figs. 721, 723 ♂, 722 ♀ (London).

NOTES ON AMERICAN PHYMATIDAE II (HEMIPTERA, REDUVIODEA).

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ABSTRACT

The author discusses the status of the family Phymatidae, recently degraded by Carayon, Usinger and Wygodzinsky to the subfamily rank and included into the family Reduviidae. He comes to the conclusion that this is unfortunate since it was based on a couple of species belonging to only one genus of the subfamily Phymatinae compared with two aberrant subfamilies of the family Reduviidae, Holoptilinae and Elasmodeminae. The author proposes to conserve the well established family Phymatidae as a family and to include Themonocorinae as a new subfamily into it.

The species *Macrocephalus incisus* Stål 1862 is revalidated and separated from *Macrocephalus notatus* Westwood, 1843, into which synonymy it was put by Handlirsch in 1897 and a key for the separation of these two species and their respective subspecies is given. Three new species of the genus *Macrocephalus* (subgenus *Lophoscutus* Kormilev, 1951) are described: *M. margaritis* from Mexico, *M. drakei* from Cuba and *M. subproductus* from Puerto Rico.

Through the kind offices of Drs. Eva Halaszfy, Carl J. Drake, and J. F. G. Clark, I have had the opportunity of examining a certain number of American Macrocephalinae (Phymatidae) from the collections of the Hungarian Museum in Budapest, and the United States National Museum. To them I express my sincere thanks.

In 1958 Carayon, Usinger, and Wygodzinsky published a joint paper on the classification of the Reduviidae (1958:256), in which they proposed some cardinal changes in the status of the family Phymatidae, reducing it to sub-family rank and including it in the family Reduviidae. With all due respect to these eminent hemipterologists, I cannot concur with their proposition and think that it was most unfortunate. Instead of clarifying an already heterogenous family, with some 30 subfamilies, they unnecessarily made it more complicated. Their conclusions based mainly on the discovery of a new tribe, the Themonocorini, which possesses a certain number of characters present also in

the Phymatinae (as a subfamily of the Phymatidae), and others present in the Elasmodeminae and Holoptilinae, both subfamilies of the Reduviidae. From the Phymatinae they selected only a few species of the genus *Phymata* Latr., 1802, leaving other genera and both other subfamilies (the Macrocephalinae and Carcinocorinae) of the Phymatidae out of consideration. From the Reduviidae they separated the Holoptilinae, an aberrant subfamily itself, the systematic position of which within the family Reduviidae is not clear, and the Elasmodeminae, also an aberrant subfamily which at one time was considered an independent family by the third author (1944:193).

It is significant that almost at the same time when the paper in question was published, an American hemiperologist, N. T. Davis, published a very thorough piece of research on the internal genitalia of the Phymatidae, as a part of his comparative study of the morphology and phylogeny of the Reduvioidae. He does not question the validity of the Phymatidae as a family. (1957: 432).

The three authors in discussing the relationship of their new "tribe" Themonocorini with the Reduviidae and Phymatidae, came to the conclusion that the Themonocorini with the Phymatinae (as a subfamily) made a natural grouping taxonomically equivalent to the Elasmodeminae and Holoptilinae; but they did not answer the question as to whether or not these are more closely related to one another than to the Reduviidae, and thus should not form a separate family equivalent to the rest of the Reduviidae.

Why was it necessary to degrade the long established family Phymatidae to subfamily status and place it in the already heterogenous and ill defined family Reduviidae before the latter has been brought out of chaos itself? Before the thorough comparative revision of the entire reduvioid complex, so badly needed, is done, I still propose to retain the Phymatidae as a family, and include the Themonocorini in it, not as a tribe but as a subfamily, the Themonocorinae.

China and Miller (1959:33) also consider the Phymatidae as a family and consider the Themonocorinae as primitive phymatids with subfamily status therein.

The subfamily Macrocephalinae is represented in America by two genera: a monotypic, archaic genus *Extraneza* Barber, 1939,

so far known by a single specimen from Porto Rico, and *Macrocephalus* Swederus, 1787. The latter was split by me into two subgenera: *Macrocephalus* sens. str., and *Lophoscutus* (1951) on the basis of differences in the shape of the paramere, the former having the paramere with a subapical branch more or less bifurcate at the tip and the apex of the main trunk bearing bristles, and the second having the main trunk bent at a different angle, and tapering to an acute apex without bristles. *Macrocephalus* sens. str. as far as I can establish has a spear-shaped or arrow-shaped, ivory spot on the base of a median carina which extends $\frac{1}{4}$ to $\frac{2}{3}$ the length of the scutellum. *Lophoscutus*, on the other hand, has only a thin median carina extending from the base to the apex of the scutellum. There are still to be studied some species with poorly defined spots on the scutellum. I have refrained from considering these two as separate genera as proposed by Maa (1956:109). The second type of paramere, i.e. as found in *Lophoscutus*, is also seen in some other genera of oriental Macrocephalinae.

Within *Macrocephalus* sens. str. there is a poorly defined grouping of species called the "notatus group." The first species of this group, *M. notatus* Westwood 1843, was described from Colombia. Later Stål described two species from Mexico, *M. incisus*, and *M. cliens*. Later, in the *Enumeratio Hemipterorum*, Stål placed the latter in synonymy with the former. Handlirsch, in his revision of the Phymatidae, could not separate *incisus* from *notatus* because of the pronounced variability of the ivory spot on the scutellum, the width of the connexiva, and the length of the antennal segments; he therefore synonomized all under the name *notatus*. I have always had a feeling that *notatus* and *incisus* are different, though closely related, species, but was unable to prove it, not having enough material for comparison. Only now, having accumulated a rather large series of *Macrocephalus* from Brownsville, Texas, Mexico, Honduras, Guatemala, Costa Rica, Panama, and Colombia, have I had the chance to verify my contention. As so often happens in the Phymatidae in general, some species distributed over large areas show an inclination to form geographical subspecies with poorly defined limits. Only after a large series of specimens taken from a wide range of distribution have been studied can valid conclusions be reached. It is particularly difficult to separate species, particularly in the

case of females, when only a single or a few specimens are available.

Genitalia are not of much help either, particularly in the females, being both similar and variable at the same time.

In the case of the "notatus group," the separation of the species, and subspecies, may be best shown with the key for the males:

1. Ivory spot of the scutellum shorter, reaching usually to the hind border of connexivum IV, or to the middle of connexivum V (IV visible); parameres with the lateral, subapical branch of the parameres more or less bifid at the tip *M. notatus* Westwood, 1843.
- . Ivory spot of the scutellum longer, reaching to the hind border of connexivum V, or to the middle of connexivum VI; lateral, subapical branch of the parameres is never bifid, more or less rounded at the tip *M. incisus* Stål, 1862

M. notatus may be tentatively separated into two geographical subspecies: *M. notatus* s.str., distributed in Colombia and Panama, and *M. notatus costa-riquensis* n.ssp., distributed in Costa Rica. These subspecies may be separated by the following key for the males:

1. Ivory spot of the scutellum spearshaped, produced, and pointed posteriorly; connexiva III, and IV, relatively wider, ratio between the length and width about 1:0.73, and 1:0.78 respectively; parameres only slightly bifid *M. notatus* s.str. (Fig. 1-2).
- . Ivory spot of the scutellum much abbreviated, arrow-shaped, more or less obtuse posteriorly; connexiva III, and IV, relatively narrower, ratio between the length and width being about 1:0.62-0.66 in both connexiva; parameres strongly bifide
M. notatus costaricensis n.ssp. (Fig. 3-5).

M. incisus Stål also may be tentatively separated into two geographical subspecies: *M. incisus* s.str., distributed in SW corner of Texas, and through Mexico; and *M. incisus maya* n.spp., distributed in Guatemala and Honduras. This subspecies may be separated by the following key for the males:

1. Connexiva III, and IV, are relatively wider; the ratio between the length and width is about 1:0.73-0.74, and 1:0.71-0.85 respectively; lateral branch of the parameres is subtruncate apically
M. incisus s.str. (Fig. 6-7).
- . Connexiva III, and IV, are relatively narrower; the ratio between the length and width is about 1:0.58-0.61, and 1:0.53-0.66 respectively; lateral branch of the paramere is rounded apically
M. incisus maya n.ssp. (Fig. 8-9).

I confess, that I was unable to make a satisfactory key for the females, either of *M. notatus*, or *M. incisus*, they having not parameres, (the best character for separating the males) and lacking well defined ratio between the length and the width of connexiva III and IV. Only that the ivory spot of the scutellum in *M. notatus costa-riquensis* is mostly much shorter than in any other subspecies of this group, is what helps in separating it at first sight from the others. In *M. incisus* Stål the shape of the ivory spot ranges from fusiform to somewhat abbreviated posteriorly, but still pointed; its lateral sides are mostly rounded, but sometimes subangular. In *M. incisus maya* the ivory spot is always rounded laterally, and mostly more convex than in *M. incisus* s.str., though some specimens of the latter from Mexico also have very convex and relatively shorter spot, as in ssp. *maya*. In this case they can be separated by abdomen, which in *maya* is a little less flaring than in *incisus* s.str., connexivum being a little narrower. Ivory spot in *M. notatus* s.str. is similar to *incisus* s.str., but is easily separated, as stated, from the ssp. *costa-riquensis* by its form, which is in the former fusiform, and in the latter arrow-shaped, or spear-shaped, with a very abbreviated posterior part.

Material examined:

I. *Macrocephalus notatus* Westwood.

One ♂, Bonda, Colombia (Dr. C. = Drake collection in U.S.N.M.); 1 ♀, S. Marta, Colombia—Geo M. Green coll., XII. 26.10 (U.S.N.M. = U.S. National Museum, Washington, D.C.); 1 ♀, Santa Maria, Colombia—Santschi II, 1896 (H.N.M. = Hungarian National Museum, Budapest); 1 ♀, Rio Frio, Colombia, VI.28.25 (K.C. = Kormilev collection, Brooklyn, N.Y.); 2 ♂, Pedro Miguel, Panama (U.S.N.M. & K.C.); 1 ♂, Summit at Panama CZ, on Lantana,—N.L.N. Kraus coll., VI.53 (U.S.N.M.); 1 ♂, Panama, Panama—E. A. Schwarz coll IV.15.11 (K.C.); 1 ♂, Ancon, Panama CZ, E. A. Schwarz, IV.13.11 (U.S.N.M.); 1 ♀, Panama—Yale Peruvian Exp., with label “*Macrocephalus Bergrothi* Handl., det. E. H. Gibson” (U.S.N.M.).

II. *Macrocephalus notatus costa-riquensis* n.ssp.

Holotype male, Santa Ana, Costa Rica—Bierig, VI.13.46, deposited in the Kormilev collection.

Allotype female, Piedras Negras, Costa Rica—Schild-Burgdorf, collector, deposited in the U.S. National Museum, Washington, D.C.

Paratypes 1 ♂ & 4 ♀, Piedras Negras, Costa Rica—Schild-Burgdorf coll. (U.S.N.M. & K.C.); 1 ♂ & 1 ♀, Rosario, Cuzeatan VII.17.55, M.S.V. coll. (U.S.N.M.); 1 ♂, Turrialba, Costa Rica—Schild-Burgdorf coll. (H.N.M.); 1 ♀, Tucurrique, Costa Rica (H.N.M.); 1 ♀, Surrubres, Costa Rica (H.N.M.).

III. *Macrocephalus incisus* Stål.

3 ♂ & 4 ♀, Brownsville, Texas, U.S.A. (U.S.N.M.); 1 ♂, Mex(ico)—C. F. Baker coll. (U.S.N.M.); 1 ♂, Venodio, Sin., Mex(ico)—Kusche VI.19.18 (U.S.N.M.); 2 ♂, Vera Cruz, Mexico (U.S.N.M. & K.C.); 1 ♂ & 1 ♀, Cordoba, Vera Cruz, Mexico—F. Knab coll. (U.S.N.M.); 1 ♂, Tampico, Mexico—F. C. Bishopp coll. XII.5 (U.S.N.M.); 2 ♀, Calhoun Co (Texas?) (U.S.N.M.); 1 ♀, Vera Cruz, Mexico (K.C.); 2 ♀, Colima, Mexico—L. Conrad coll. (U.S.N.M.); 1 ♀, Tampico, Mexico—E. A. Schwarz coll. (U.S.N.M.); 1 ♂, Colima, Mexico—(H.N.M.); 1 ♀, Teapa, Tabasco, Mexico, with a label “B. C. A. Rhynch. II—*Macrocephalus notatus* Westw. ♀” (H.N.M.); 1 ♀, Mexico, with labels: “Coll Signoret,” and “*notatus*, det. Handlirsch” (H.N.M.).

IV. *Macrocephalus incisus maya* n.ssp.

Holotype male, Trece Aguas, Alta V. Paz, Guatemala—Schwarz & Barber coll., deposited in the U.S. National Museum, Washington, D.C.

Allotype female, collected with the holotype; deposited in the same museum.

Paratypes 3 ♂, Trece Aguas, Alta V. Paz, Guatemala (U.S.N.M. & K.C.); 1 ♂, Tegucigalpa, Honduras—F. Dyar coll. IV.3.17 (U.S.N.M.); 1 ♀, Livingston, Guatemala—Barber & Schwarz coll. 11.5 (U.S.N.M.); 2 ♀, Morales, Guatemala—J. J. White coll. VIII.28 (U.S.N.M. & K.C.); 1 ♀, Mexico—Procopp coll., with label “*notatus*, det. Handlirsch” (H.N.M.).

Among the *Macrocephalus* species, which I have examined, were two new species from the collections of the U.S. National Museum, from Mexico, and Puerto Rico respectively, the first labeled by Dr. Reece I. Sailer as “*Macrocephalus sp.?*”; and one striking new species from Cuba, collected by Mr. Zayas, and kindly sent to me by Dr. Carl J. Drake for identification.

1. *Macrocephalus margaritis* n.sp.*

(Fig. 10-11).

Elongately ovate; male more than three times, and female almost three times as long as wide (♂—178:55, ♀—197:67); densely covered with round, shiny, pearl-like granulation.

MALE: HEAD much longer than wide through the eyes (♂—35:23, ♀—37:25); antecular lateral border as long as the postocular (12:12); anterior border deeply cut out; ocelli dorso-lateral, placed on the small swellings. Antennae moderately slender; the 4th segment a little shorter than the 2d and 3d together (♂—15:17, ♀—13:16). Proportions of the antennal segments, 1 to 4, are: ♂—12½(7½):7(4):10(3½):15(7), ♀—12(8):7(4):9(4):13(7), the figures between brackets represent the width of the segment.

PRONOTUM elongate, rather flat, slightly declivous forward, shorter than wide across the humeri (♂—45:53, ♀—47:57); anterior border widely cut

* Μαργαρίτης = pearl. This species is covered with a dense, shiny, pearl-like granulation.

out; anterior angles acute, slightly divergent; antero-lateral-anterior borders almost straight, with a blunt, semispiculoid granulation; antero-lateral-posterior also almost straight, angle between the first and the latter is about 68° ; lateral angles regularly rounded, neither reflexed, nor cut out; postero-lateral borders firstly convex, then concave; posterior border convex; posterior angles small, but prominent. Fore disc more convex, densely covered with blunt, semispiculoid granulation; the pit on the median line small, but deep. Interlobal depression deep and sharply marked. Posterior disc flatter; carina are blurred, discernible only on the first third of the disc. Hind disc covered with round, pearl-like granulation, and between the granules with fine, but deep punctures.

SCUTELLUM elyptoid in shape, more than twice (δ), or almost twice (φ) as long as wide (δ —98:46, φ —111:57), reaches to the tip of the abdomen. Its lateral borders are regularly convex from the base to the tip, without subbasal constriction. Median carina fine, low, but well marked up to the tip of the scutellum; its basal $\frac{1}{8}$ is slightly widened. Disc densely covered with round, pearl-like granulation, and between it with fine, but deep punctures.

HEMELYTRA reach to the tip of the abdomen; corium is narrow; in the basal half with two rows (lateral and on the vein) of very fine granules; in the apical half with a row of very fine punctures.

ABDOMEN elongate, with a narrow connexivum, which is partly seen from segments II to V (δ), or from II to VII respectively (φ). Abdomen is longer than wide (δ —78:55, φ —88:67). Connexiva granulate only on the border (δ), or also on the discs (φ).

STERNUM mesosternal cross slender and high, its fore branch with few small granules.

FORE FEMORA moderate in size, more than twice as long as wide (δ —35:16, φ —37:18).

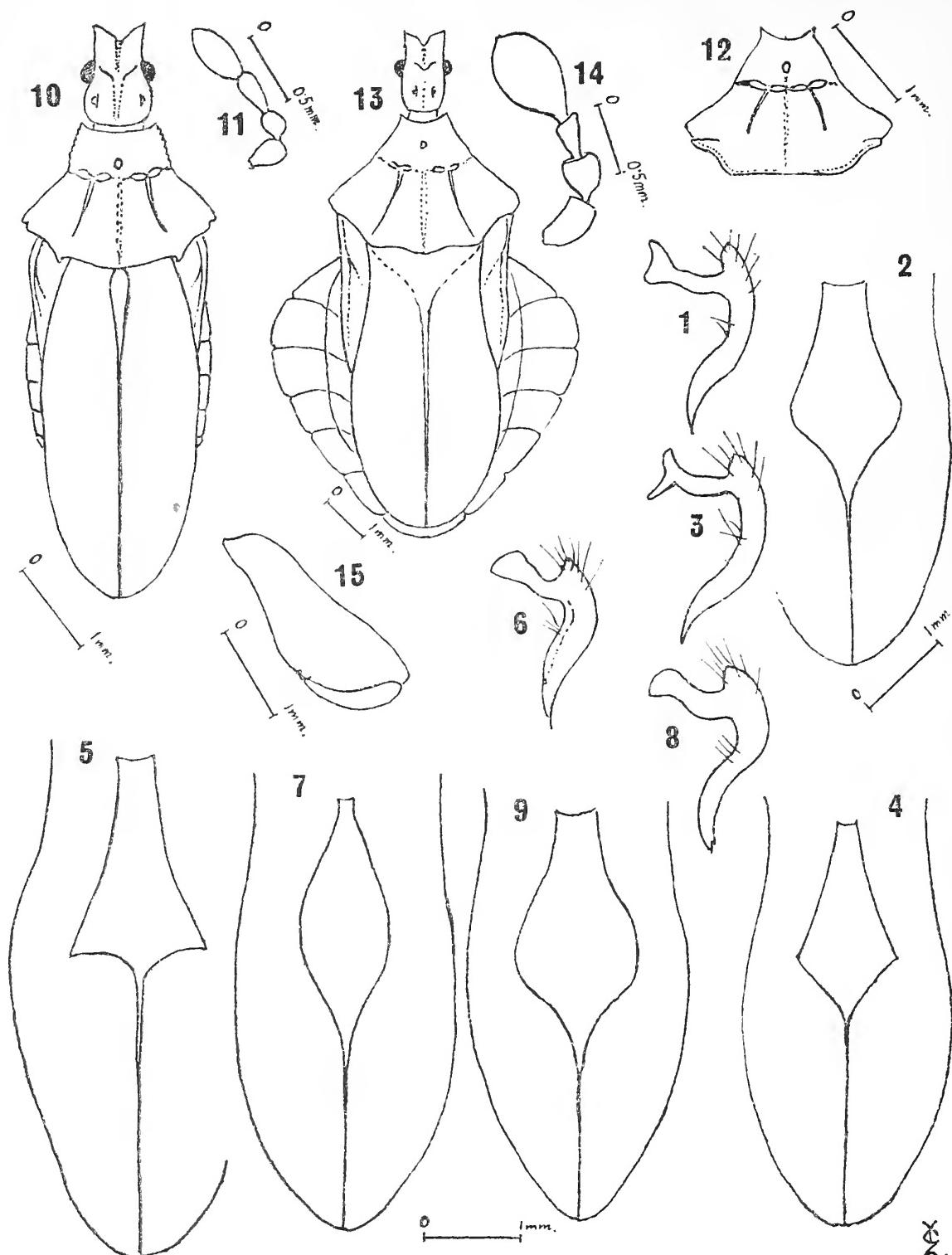
COLOR: male: pale yellow, on the fore disc of the pronotum becoming yellow; a few dots and spots brown to piceous; antennae sometimes partially reddish; inner apical part of the corium carmin-red. Female: pale salmon, sometimes orange-yellow, with white granulation; fore disc of the pronotum, and the head partially, orange red to carmin red; inner apical part of the corium carmin red.

Total length: δ —5.93, φ —6.56 mm.; width of the pronotum δ —1.76, φ —1.90 mm.; width of the abdomen δ —1.83, φ —2.23 mm.

HOLOTYPE: male, Malz, S.L.P., Mex(ico), Lar. Tex. 48446; 3.31.1949, on Orchids. Deposited in the U.S. National Museum, Washington, D.C.

ALLOTYPE: female, Arriaga, Chiapas, Mex(ico); Laredo, Tex. 55238; I.15.1955; on Orchids. Deposited in the same Museum.

PARATYPES: 1 δ , Mexico, on Bromeliads, 3.1.1955, and 1 δ , Tegucigalpa, Honduras, Febr. 13, 1918, F. J. Dyar; with a label “*Macrocephalus* sp., det. H. G. Barber”; both in the U.S.N.M. 1



EXPLANATION OF DRAWINGS

1. *Macrocephalus notatus* Westwood, right paramere.
2. " " " , ♂, ivory spot on the scutellum.
3. *Macrocephalus notatus costa-riquensis* n.spp., right paramere.
4. " " " , ♂, ivory spot on the scutellum.
5. " " " , ♀, " " " "
6. *Macrocephalus incisus* Stal, right paramere.
7. " " " , ♂, ivory spot on the scutellum.
8. *Macrocephalus incisus maya* n.ssp., right paramere.

♂, Tegucigalpa, Honduras, F. J. Dyar, and 1 ♀, Ruxtla, Chiapas, Mex (ico), on Orchids; both in the collection of the author.

The new species stands rather isolated in the genus. It is somewhat similar to *M. insularis* Dudich, 1922, but is more elongate; scutellum without subbasal constriction, its median carina is only slightly widened at the basal $\frac{1}{8}$; the granulation is bigger; also the color is much lighter. *M. margaritis* n.sp. belongs to the subgenus *Lophuscatus*.

2. *Macrocephalus subproductus* n. sp.
(Fig. 12).

FEMALE Elongately ovate, with moderately flaring abdomen; granulation is fine, white, and dispersed.

HEAD longer than wide through the eyes (30:22), anteriorly deeply cut out; eyes big, semiglobose; ocella dorso-lateral, placed together on a low elevation. Antennae thin, the 4th segment thick, ovate, longer than the 2d and 3d together. Proportions of the antennal segments, 1 to 4 are: 8(5):5(4):7(3):14(7½).

PRONOTUM shorter than wide across the humeri (42:65); fore border deeply cut out; anterior angles acute, and slightly divergent; antero-lateral-anterior borders slightly convex in the middle; antero-lateral-posterior borders firstly slightly concave, then slightly convex; lateral angles slightly raised, rounded at the tip, and slightly cut out behind the latter. Postero-lateral borders firstly convex, then concave; posterior border almost straight; all borders finely granulate. Fore disc convex, granulate; interlobal depression well marked; hind disc with rough punctures, and a few granules near the fore border, and on the borders. Carinae granulate anteriorly, run out at 3/5 of the disc's length.

SCUTELLUM almost reaches the tip of the abdomen; more than twice as long as wide (97:46); in the basal $\frac{1}{4}$ roughly, then finely punctured; in its posterior $\frac{2}{3}$ with a fine, white, dispersed granulation. The maximal width of the scutellum is a little behind the middle. Looking from the side the median carina is a little depressed just behind the base, then straight. Carina is thin and low, but runs to the tip of the scutellum; at the basal 1/6 is slightly widened.

HEMELYTRA. Corium finely punctured, and with scarce, dispersed granulation; the tip of the corium is smooth.

ABDOMEN almost as long as wide (78:77), from segments II to V partially seen from above. Connexivum moderately wide; connexiva III and IV longer

-
- 9. " " " , ♂, ivory spot on the scutellum.
 - 10. *Macrocephalus margaritis* n.sp., ♂.
 - 11. " " , ♂, antenna.
 - 12. *Macrocephalus subproductus* n.sp., ♀, pronotum.
 - 13. *Macrocephalus drakei* n.sp., ♀.
 - 14. " " " , ♀, antenna.
 - 15. " " " , ♀, fore femur & tiba.

than wide. Antero-lateral borders barely convex; postero-lateral straight; lateral angles widely rounded, and slightly raised; PE—angles (postero-exterior) of the connexiva slightly protruding.

Gonapophyses 3 are elevated, and compressed from the sides, forming a short, high ridge, split along the median line, a character which I have not seen in any other species of *Macrocephalus*.

FORE FEMORA less than twice as long as wide (42:23), with a white setigerous granulation at the upper side, the rest of the disc is smooth.

COLOR: pale orange-yellow; head, antennae, hind disc of the pronotum, the tips of the fore femora, and fore tibiae, are testaceous; the tip of the corium, and the transversal band of the abdomen are dark orange, partially carmin-reddish. Membrane brown.

FEMALE Total length 5.66 mm.; width of the pronotum 2.16 mm.; width of the abdomen 2.56 mm.

HOLOTYPE: female, Laras, Puerto Rico—G. N. Wolcott coll. 9.6, 1921; deposited in the U.S. National Museum, Washington, D.C.

M. subproductus n.sp. is closely allied to *M. productus* Barber, 1939, but the head is relatively narrower, particularly behind the eyes; fore lobe of the pronotum less convex; lateral angles of the same are not produced into long, sharp, raised points, but only moderately extended and slightly cut out behind the tip; lateral angles of the abdomen are regularly rounded, and not produced into big, rounded lobes; fore femora relatively smaller. Belongs to the subgenus *Lophoscutus*.

3. *Macrocephalus drakei* n.sp.
(Fig. 13-15).

FEMALE Feebly convex, rather long, pronotum, with subtruncate lateral angles; wide, cordate abdomen. Color ferruginous; granulation on the head, and antero-lateral borders of the pronotum yellowish.

HEAD cylindrical, much longer than wide through the eyes (31:20); finely granulate. Antennae slightly longer than the head (35:31); first segment subcylindrical, slightly widening toward the tip, seeing from above twice as long as wide; second subglobose, slightly longer than wide; third slender, tapering toward the base, more than twice as long as wide; fourth fusiform, inflated, less than twice as long as wide. Proportions from 1 to 4 are: 10(5):5(4):7(3):13(8). Jugae truncate anteriorly.

PRONOTUM relatively long, narrowed anteriorly, and strongly widening backward; shorter than wide across the humeri (55:75). Anterior border slightly and roundly cut out; antero-lateral angles short, acute, somewhat divergent; lateral borders of the fore lobe divergent backward, roughly and densely granulate; antero-lateral borders of the hind lobe more divergent, with granulation becoming finer toward the humeri; lateral angles obliquely subtruncate, almost rounded, horizontal, neither raised, nor cut out

Postero-lateral border cut out behind lateral angles; hind border slightly convex. Fore disc inflated, with sparse, fine granulation, but without punctuation; a pit on the median line placed a little behind the middle; median line marked as very fine furrow. Hind disc roughly punctured, but without granulation; carinae low, but evenly marked on the whole length; parallel anteriorly, then divergent.

SCUTELLUM more than twice as long as wide (110:51), reaches to the middle of connexivum VIII; lateral borders sinuate at the first fifth of its length, then convex; disc triangularly inflated at the base; median carina thin and low, slightly inflated only at the basal 1/7 of its length. Basal fifth of the disc roughly, the rest of it finely, punctured.

ABDOMEN cordate, shorter than wide (100:113); connexiva from II to VII, and part of the tergum, are in the open; connexivum VIII is partly visible behind the scutellum; discs of the connexiva are finely granulate. PE- angles not protruding, but as the antero and postero-exterior angles of the connexiva are rounded, they are clearly marked. Venter strongly convex, finely granulate.

Mesosternal cross thin and high, smooth, without granulation. Propleura finer, meso and metapleura (in lower part) more roughly granulate. Antero-inferior angles of the propleura with a few, small, blunt teeth.

FORE FEMORA relatively small, almost three times as long as wide (47:17), very finely granulate, and with a few, scattered bigger granules.

COLOR ferruginous, partly darker; granulation ivory; pleurae reddish yellow to testaceous; venter testaceous; fore femora blackish to ferruginous; middle and hind legs black, with ivory granulation; middle and hind tarsi brown to ferruginous.

FEMALE Total length 10.0 mm.; width of the pronotum 3.75 mm.; width of the abdomen 5.65 mm.

HOLOTYPE: female, Loma del Gato, Oriente, Cuba—F. de Zayas coll. VI.1959; deposited in the collection of Mr. Zayas.

The new species is rather isolated in the genus; should belong to the subgenus *Lophoscutus* Kormilev, (parameres ?).

It is a pleasure to dedicate this striking species to Dr. Carl J. Drake of the Smithsonian Institution.

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In The Field

During April, May and June 1962, Doctor Herbert Ruckes, Research Associate in the Department of Entomology of the American Museum of Natural History will carry on field work in Panama and Costa Rica. His major objectives will be to collect heteroptera and to make observations on their habitats and behavior. The hemipteran fauna of these areas, while previously studied, is still not completely understood and museum material from Central America is not plentiful. It is hoped that a considerable number of specimens will be brought back.

BOOK REVIEW

1001 QUESTIONS ANSWERED ABOUT INSECTS. Alexander B. and Elsie B. Klots. Illustrated with photographs by A. B. Klots and line drawings by E. B. Klots and Su Zan N. Swain. Dodd, Mead and Company, published October 1961, 260 pp., price \$6.00.

This book is the latest addition to the Dodd, Mead natural history series. Insects are the subject, and 1001 questions answered is the format. The publishers are fortunate in their authors and illustrators, for three eminently qualified experts have produced this volume.

The chapter titles provide the topical groupings for the questions. Thirteen chapters cover thirteen broad areas: insects and their relatives; origin; classification; distribution and ecology; structures; development; senses; behavior; societies; aquatic insects; insects and plants; insects and other animals; insects and man. Material on commonly seen arachnids is included in the last chapter.

The scope of the book is extensive. The authors do not confine themselves to the groups in which they have specialized but explore the wide range of orders. The questions not only pique the interest of the reader but also give rise to answers which, in total, develop a well-rounded entomological background. Frequent references are drawn from the authors' extensive field observations. Thus, practically all areas of insect study are exposed. The tone of the answers is pleasantly conversational and scientifically accurate.

The use of a book of this kind as a reference depends, in great measure, upon the index. The authors have fulfilled this requisite; the index is full and workable with cross-references.

A. B. Klots has provided 31 black and white photographs which are grouped and inserted in the center of the book. They are representative of his photographic work, which has delighted entomologists. The line drawings are clean-drawn and exact and add to the informative quality of the answers.

No book entirely escapes its reviewer's criticisms. In this case they are very minor. A couple of times I wished for a slightly different distribution of the emphasis in answers. Also, I wonder

if it would not be more exact to have used the word "bite" instead of "sting" when describing the aquatic bugs in question 618 and the spiders in 984?

Both professional entomologists and amateurs will find the Klots' book a useful one. The professional needs to keep abreast of the large and complex insect group, and the amateur needs to be awakened to this fascinating field in natural history. Science continues to reveal new facts daily. This volume, which has collected and sorted many such facts for its readers, can be considered one of entomology's happy contributions along the way.

—J. FORBES

INSECT TRAVEL—by jet and by sea

High-speed jet aircraft has increased the transfer of insects from one country to another and the World Health Organization has found that insects which normally would be killed by long hours of exposure to cold, may survive short jet trips between countries. Documented cases show that insect eggs laid on aircraft, survived the cold at altitudes of 25,000 feet for several hours and still hatched. On a lower level, the Michigan Dept. of Agriculture has discovered nearly 30 alien pests transported there since the opening of the St. Lawrence Seaway that now brings traffic to Michigan ports from all parts of the world.

—by air

A current study being conducted under a National Science Foundation Grant by Carl J. Mitchell, seeks to determine the mode of dispersal of arthropods throughout the Pacific. Dr. Mitchell of the Bernice P. Bishop Museum at Honolulu has flown about 74,000 miles between August and December of 1961 to trap high-altitude free-soaring insects. The entomologist flies in a Constellation cruising at about 200 m.p.h., fitted with a specially designed insect trap fifteen feet long.

**JOURNAL
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HOW TO COLLECT *CALIGOS* IN THE CARIBBEAN (LEPIDOPTERA: BRASSOLIDAE)

BY BERNARD HEINEMAN

RECEIVED FOR PUBLICATION OCTOBER 18, 1961

Saturday evening, January 21st, 1961 saw us at the airport at Port of Spain in Trinidad, B. W. I.

It was hot. The small waiting room was jammed with people who, like us, were flying to Tobago; or with friends waiting to greet folks on an incoming plane from Martinique; or there to say good-bye to passengers about to depart on a giant airliner for London.

Every seat in the waiting room was occupied and standing room itself was at a premium. Suddenly the arrival of the plane from Martinique was announced, causing a rush of sweating humanity to the fence to wave to incoming passengers.

What a relief for us! We took seats, deposited hand bags, coats, (we were soon to return to New York's winter weather) and butterfly nets, and relaxed. But not for long. Mrs. Heineman's eagle eye began to roam and espied a large insect perched atop the molding inside an unoccupied room with a sign on it: "Director of Civil Aviation." (The room, not the insect.) "Isn't that *Erebus odorata* up there?" she said, pointing to the insect aforementioned—forgetting completely that her parents had taught her that it was impolite to point. Wearily I arose from my newly acquired seat (I had been up most of the night collecting moths at "Simla" the Research Station of the New York Zoological Society so superbly run by Dr. William Beebe and his gracious aide, Miss Jocelyn Crane). *E. odorata*, the big black, gaudy moth, was common enough, but I didn't have one from Trinidad. So, tired as I was, I went to look at it, only to be spurred into instant action. Off came my coat and my clip-on bow tie. Out came a net to be set up and pieced together hurriedly, and into the unlocked room of the "Director of Civil Aviation" went Heineman to swing wildly at what was not *odorata* at all but what appeared to me (in my ignorance) to be a *Morpho* different from ones that I had taken in the rain forest the

day before. Alas for me, my net fell short, but the swish dislodged the butterfly which flew out the other door of the Director's room into the area in which customs inspectors were examining the baggage of passengers who had just deplaned.

Oblivious to the fact that I was behind the long baggage tables with the uniformed officials, I continued my frantic swings to no avail. All business stopped. Some of the inspectors themselves joined in the chase, clapping their hands together at the big butterfly whenever it came low enough. This resulted in its departing for another restricted area where immigration authorities were examining passports. Undaunted and intrepid I climbed over the chains that meant "no trespassing" and continued my pursuit.

A vicious swing and a high jump, and I heard a voice cry out with a British accent "He's got it." I felt that the entire chorus of "My Fair Lady" was singing my praises and marched proudly back with the catch to my patient and embarrassed wife. Now, what to do with this large insect with its $4\frac{1}{2}$ " wing spread? "There's a dirty handkerchief that someone dropped" she said. So, delicately, we folded it in the handkerchief and carefully stowed it in the outside pocket of our K.L.M. bag. I drew a deep breath and gave a sigh of relief. But relief was not at hand. "Isn't that another one?" said the wife, nodding towards a room marked "Swiss Bank." My better three-quarters is never wrong. Of course it was another.

This time I was smarter. No rushing, no excitement. "Take your time, man. Easy does it." So I said, quietly, to the teller behind the cage window: "Would you permit me to come in and catch that butterfly, please?" He looked at me with a frightened expression as if to say: "This is either a stickup or the man is crazy" (which all of us entomologists are, of course). "Please," I begged. "Our plane is leaving any moment." Gingerly, he opened the door, one hand on his hip pocket. This time I stood on a chair and picked my beauty off as if it had been an apple on a tree. A quick pinch of the thorax, a triangle made from an old discarded newspaper, and our second treasure was packed away in the other side pocket of the K.L.M. bag just as the departure of our plane was announced.

Rushing back into tie and coat, with net folded away and bags in hand, we started for the boarding gate when a petite woman,

with two small children clinging to her, approached us saying in a timid voice: "Would you care for this one, sir?"

Believe it or not she had caught a third one in her fingers and presented it to us in perfect condition.

A week later we changed planes at Trinidad en route from Tobago to Barbados. I had time to amble into the immigration and customs area for another look. One of the uniformed officials recognizing me, said: "Mister, there was another one here the other night after you left."

Back home we identified them easily as *Caligo insulanus*, Stich. What was this magnificent butterfly doing in an airport at night in such numbers? It is known to fly at dusk. Did the lights attract it or was it possibly drawn in by the odor of bananas, which may have been growing or stacked in the vicinity?

Under any circumstances, you patient readers—if you have been with us this far—should now know how and what to do to collect *Caligos* in the Caribbean.

THE IMMATURE STAGES OF MATRIOPTILA JEANAE (ROSS) (TRICHOPTERA: GLOSSOSOMATIDAE)

BY OLIVER S. FLINT, JR.

SMITHSONIAN INSTITUTION, WASHINGTON

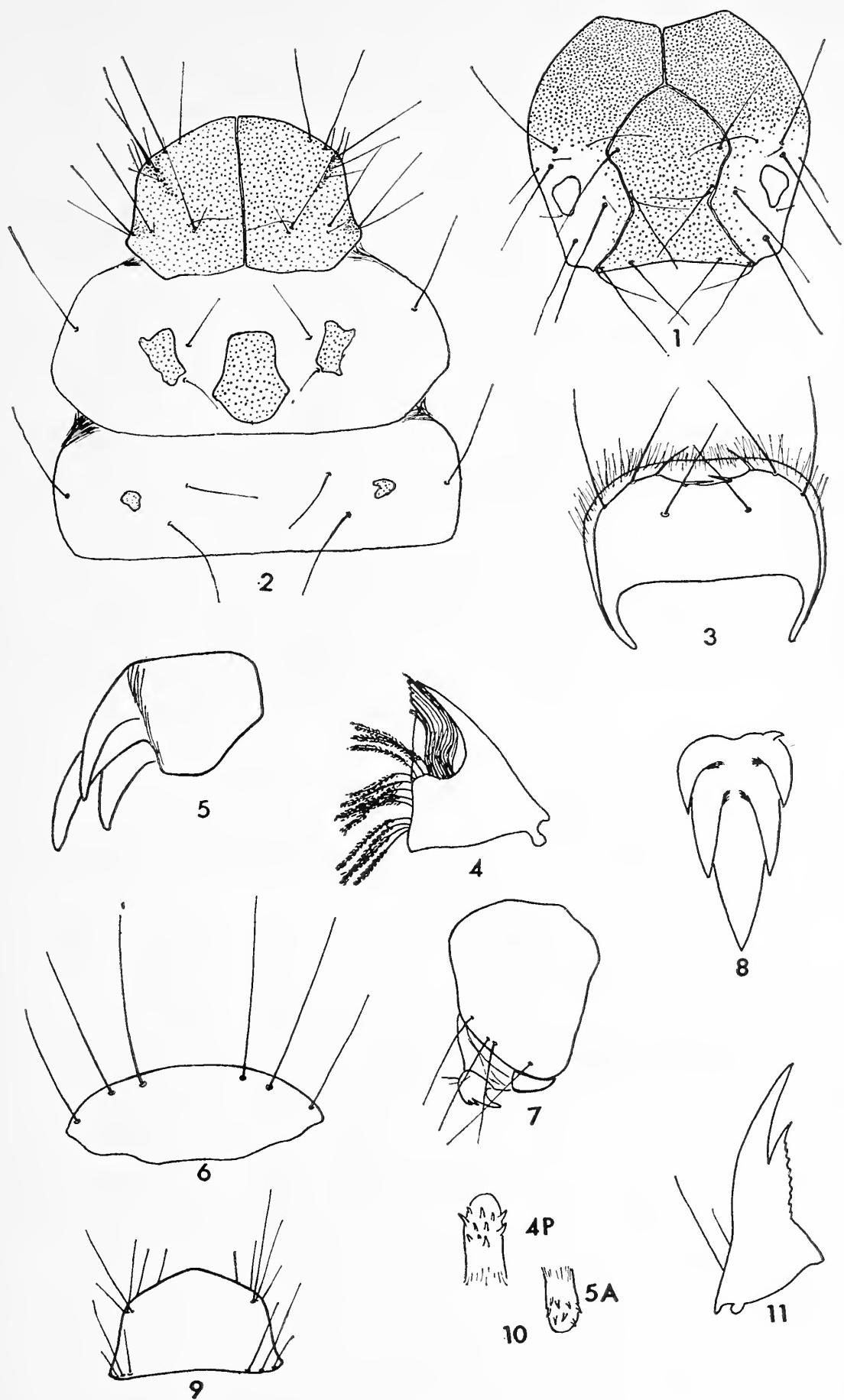
RECEIVED FOR PUBLICATION JULY 20, 1961

ABSTRACT

The larvae, pupa and case of this species are described for the first time. The immature stages substantiate the separate generic status recently given the species.

Ross established in 1956 the genus *Matrioptila* for his *Protoptila jeanae*, described in 1938, which is known only from the Southern Appalachian Region of North America. The immature stages, however, have remained undescribed until the present. Many larvae and pupae were collected on June 6, 1961, in the East Fork of the Chatoga River where it flows through the Walhalla Federal Fish Hatchery near Walhalla, South Carolina. Included in the collection are several male and female pupae with fully developed genitalia that permit positive association of stages.

LARVA Length 2.5mm., width .75mm. **Head** Brown, yellow around eyes and anteriorly on venter (fig. 1). Labrum as in fig. 3; mandibles similar (fig. 4), but right one with 3 or 4 fewer feathered setae; maxillo-labium obscure. **Thorax** Tergites brown; legs pale brown to yellow; three pairs of setae present on meso- and metanota (fig. 2). Sternites typical of family: prosternum anteriorly with a pair of large wing-like sclerites, posteriorly with 2 narrow longitudinal sclerites; meso- and metasterna each with a pair of narrow transverse sclerites along posterior margins. Ventro-lateral setae at apex of all tibiae very long and strongly feathered; ventro-mesal seta of fore tibiae about $\frac{3}{4}$ as long as laterals and not strongly feathered; ventro-mesal seta on mid and hind legs about $\frac{1}{2}$ as long as laterals and spur-like. Tarsal claws with three apical teeth; usual ventral setae apparently lacking (fig. 5). **Abdomen** Dorsally segments 1 and 8 with 3 pairs of setae; segments 2 through 7 apparently lacking antro-mesal pair. Ventrally segments 1 through 9 with



EXPLANATION OF PLATE

Matrioptila jeanae (Ross). FIG. 1. Larval head, anterior. FIG. 2. Larval thorax, dorsal. FIG. 3. Larval labrum, dorsal. FIG. 4. Left larval mandible, ventral. FIG. 5. Larval tarsal claw, lateral. FIG. 6. Larval ninth tergite, dorsal. FIG. 7. Larval anal proleg, lateral. FIG. 8. Larval anal claw, ventral. FIG. 9. Pupal labrum, dorsal. FIG. 10. Pupal hook plates, segment 4 posterior, segment 5 anterior. FIG. 11. Pupal mandible, dorsal.

a pair of submesal setae; segment 1 with an additional pair of setae near midline on anterior margin, each arising from a small sclerite. Tergite of ninth segment brown, with 3 pairs of long setae (fig. 6). Anal sclerites brown, proportionately short and broad (fig. 7). Anal claw with a meso-ventral tooth, and 2 pairs of dorso-lateral accessory teeth, sometimes with a small third pair (fig. 8). Anal gills, 5.

PUPA Length 2.5mm., with .75mm. Labrum roughly quadrate with 5 setae in each anterior setal group and 3 in each posterior group (fig. 9). Mandibles identical, with an inner tooth minutely serrate on inner margin (fig. 11). Hook plates present anteriorly on segments 3 through 7, posteriorly on 4, each plate with 5-10 small hooks (fig. 10), hooks on posterior plates generally more numerous than on anterior plates. Apex of abdomen with lobes containing developing genitalia, and apparently without setae.

CASE Larval case 3mm. long by 1mm. wide. Made of small quartz grains in the usual form (see Ross 1944, fig. 136). Several well-defined openings left dorsally at both ends. Pupal case with ventral strap removed, slightly flatter, and with dorsal openings smaller; inner silken cocoon present.

SYSTEMATICS The Glossosomatidae are divided into two subfamilies, the Protoptilinae and the Glossosomatinae. The former is apparently restricted to the New World, whereas the latter is more widely distributed but is lacking in the Neotropical and Australian Regions, and greatly restricted in the Ethiopian Region.

The Protoptilinae contains two genera in the Nearctic Region, *Protoptila* with numerous species, and the monotypic *Matrioptila*. Numerous genera are present in the Neotropical Region, including *Protoptila*.

The immature stages of the Protoptilinae are poorly known. Ross (1944, fig. 96, 101) has illustrated a few characters of *P. lega* Ross, and I have larvae and pupae of *P. alexanderi* Ross. *Matrioptila* larvae, in comparison with *alexanderi* and *lega*, have numerous distinctive characters: tarsal claws trifid (apparently unique in the Trichoptera); seta 1 present on the metanotum; 3 pairs of long setae present on the ninth tergite; and the apparent lack of a third well-developed pair of accessory teeth on the anal claws. The pupae are a bit more difficult to separate. *P. lega*

has two teeth on the mandibles, but *alexanderi* has mandibles like those of *jeanae*. However, *alexanderi* has a hook plate anteriorly on segment 8, and the hook plate posteriorly on segment 4 is about twice the width of that on segment 5. It is possible either or both of these characters may be of generic value. The case of *jeanae* is constructed of many small sand grains giving the appearance of a small case of *Glossosoma*. The larvae of *Protoptila* use proportionately larger grains, often using only one large grain on each side of the case.

Ross (1956, pp. 150-151) shows that *Matrioptila* on the basis of adult morphology is undoubtedly a primitive genus. The presence of all three setae on the meso- and metanota is also primitive, but the significance of the remaining characters can not be assessed at the present.

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NEWS ABOUT OUR MEMBERS

Doctor Jerome Rozen, Chairman of Entomology, and Doctor Frederick Rindge of that department have both visited the United States National Museum in Washington in recent weeks to examine type specimens.

Doctor Roman Vishniac, Professor of Biology Education at Yeshiva University, known as one of the world's foremost micro-photographers, has presented a representative selection of his work to the Brooklyn Children's Museum for permanent exhibition in the museum's new science gallery. The exhibit, called "small world through the looking glass," includes thirteen micro-photographs enlarged to 24 by 30 inches by the Color Corporation of America. The pictures reveal both the drama and the beauty of microscopic life. They include the dividing amoeba, light from a rabbit's brain and an image seen through the eye of a wasp. All of the photographs were made possible by unique lighting techniques developed by Dr. Vishniac.

ACTIVITIES OF RESPIRATORY ENZYMES DURING THE METAMORPHOSIS OF THE MEDITERRANEAN FLOUR MOTH, *EPHESTIA KÜHNIELLA* ZELLER¹ (LEPIDOPTERA: PYRALIDAE)

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ABSTRACT

The occurrence of a U-shaped respiratory curve during the metamorphosis of holometabolous insects is well established. The roles of dehydrogenase enzymes and cytochrome oxidase in respiratory metabolism have been studied in some insects and these investigations indicate variations in the activities of dehydrogenase enzymes in different insects. In this study the activities of the dehydrogenase enzymes were determined during the metamorphosis of a lepidopteran, *Ephestia kühniella* Zell., using the Thunberg technique. Cytochrome oxidase was determined spectrophotometrically. Six dehydrogenase enzymes exhibited U-shaped activity curves: alpha-glycerophosphate I and II (GPD I and II), malic, isocitric and succinic dehydrogenases and the malic enzyme. The least active of this group was succinic dehydrogenase, adding support to previous work indicating that this enzyme may be a rate-limiting factor in determining the U-shaped respiratory curve. The most active of this group was malic dehydrogenase. Five dehydrogenase enzymes did not exhibit U-shaped activities: lactic I and II, glucose, glutamic and alcohol. The activities of lactic I and II dehydrogenases were low or negligible. The possible significance of this low activity with regards to (a) lactate accumulation and (b) relationship to GPD activity in insects are discussed. The activity of cytochrome oxidase was also found to be U-shaped during metamorphosis.

The occurrence of a U-shaped respiratory curve during the metamorphosis of holometabolous insects was first described by Krogh (1914) for the mealworm, *Tenebrio molitor*, and was confirmed by many investigators with various species of insects (Bodine and Orr 1925, Clare 1925, Fink 1925, Taylor 1927,

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Ludwig 1931, Dobzhansky and Poulson 1935, Wolsky 1938, Sacktor 1951, Ito 1954, Cotty 1956, Ludwig and Barsa 1956a). Comparisons of the oxygen consumption of various insects show considerable variations and Taylor (1927) concluded that there are strong indications of specific differences.

The causative factors responsible for the U-shaped respiratory curve are not definitely understood. The possible role of cytochrome oxidase as a rate-limiting factor in respiratory metabolism has been considered. This enzyme showed a U-shaped activity curve during the metamorphosis of several insects but this type of activity was not universal. A correlation between succinic dehydrogenase activity and oxygen uptake was shown for *Drosophila melanogaster* (Wolsky 1941), *Popillia japonica* (Ludwig and Barsa 1955), *T. molitor* (Ludwig and Barsa 1958) and *Bombyx mori* (Ito 1955). Agrell (1949) showed that total dehydrogenase activity and the activities of malic, succinic, citric and glutamic dehydrogenases each followed U-shaped curves during the metamorphosis of the blow fly, *Calliphora erythrocephala*. However, with the mealworm, Ludwig and Barsa (1958) found malic and succinic dehydrogenases and the malic enzyme activities to be U-shaped during metamorphosis whereas with the house fly, these same investigators (1959) found that in addition, alcohol and alpha-glycerophosphate dehydrogenases also followed U-shaped activity curves. Since these studies indicate that the activities of various dehydrogenases vary in different insects and since no study has been made of the various respiratory enzymes of a lepidopteran, except for the succinoxidase system of the silkworm (Ito 1955), this investigation of cytochrome oxidase and the dehydrogenase activities during the metamorphosis of the Mediterranean flour moth, *Ephestia kühniella* was undertaken.

MATERIAL AND METHODS

Cultures of *E. kühniella* (white eye mutant) were maintained at room temperature (approximately 25°C.) in covered culture dishes containing corn meal. Larvae collected from these cultures were placed at 30°C. in culture dishes with corn meal and examined daily for newly molted pupae. Pupae of known ages, within 24 hours, were thus obtained. Larvae, prepupae and adults used in these determinations were obtained from cultures

kept at 30°C. Stock cultures were kept at room temperature since the higher temperature rendered the males sterile.

The activities of alcohol, glucose, *l*-glutamic, alpha-glycero-phosphate, isocitric, lactic, malic, succinic dehydrogenases and the malic enzyme were determined in larvae, prepupae, pupae for each day of the pupal stage, and in newly emerged adults by the Thunberg technique as given by Umbreit, Burris and Stauffer (1957, p. 130) and as modified by Ludwig and Barsa (1958). Insects were homogenized for one minute in 0.30 M phosphate buffer, except for isocitric dehydrogenase, where veronal buffer was used since the phosphate ion interferes with the activity of this enzyme. In all cases the buffers were adjusted to a pH of 7.4. A three per cent homogenate was prepared and incubated at 30°C. for 30 minutes to oxidize the endogenous substrate. For each determination, 0.5 ml. of homogenate was required, and when DPN or TPN was needed the homogenate was incubated with 0.25 ml. of 0.2 per cent DPN or 0.25 ml. of 0.1 per cent TPN. The homogenate or homogenate-coenzyme mixture was pipetted into the side-arm cap of the Thunberg tube. In the body of the tube were placed 0.5 ml. of 1:10,000 methylene blue, 0.5 ml. of appropriate substrate (0.04 M), and sufficient buffer to bring the final volume to 3 ml. A control tube containing all the components except the substrate was prepared for each individual determination, and each control tube contained 0.5 ml. of the same homogenate mixture as was used for the determination. In determining malic dehydrogenase activity, 0.25 ml. of 0.24 M KCN was added to each tube to prevent inhibition by the oxaloacetate formed (Green 1936). In measuring the activity of succinic dehydrogenase, 0.25 ml. of a mixture of 0.005 M CaCl₂ and 0.005 M AlCl₃ was added to each tube for complete activation of this enzyme (Potter and Schneider 1942). TPN was used in the studies of isocitric dehydrogenase and the malic enzyme. In the former determinations, 0.25 ml. of 6×10^{-3} M MnCl₂ was added since the system does not react unless the Mn⁺⁺ ion is present (Adler, Euler, Günther and Plass 1939). For the malic enzyme determination, 0.25 ml. of 0.033 M MgSO₄ was added to insure activation of the enzyme (Faulkner 1956). In each case the supplementary solutions were added before the final dilution of the homogenate. The tubes, after preparation, were evacuated by vacuum pump for 5 minutes, tapping the

tube to remove dissolved gases. When evacuation was complete, the homogenate was mixed with the other components of the tube, thus bringing the final concentration of the homogenate to 0.5 per cent. The tubes were then placed in a constant temperature bath at 30°C., and the time in minutes required for 90 per cent reduction of methylene blue was determined by visually matching the color with that of the standard tube. This standard contained all components of the other tubes, the homogenate having been previously inactivated by boiling and the methylene blue diluted to 1/10 the usual concentration. Activities of dehydrogenase enzymes are expressed as 1/time in minutes for 90 per cent decoloration of methylene blue. These activities were determined for each of the enzymes as follows:

$$\text{Activity E (experimental tube)} - \text{Activity C (control tube)} \\ = \text{Activity of dehydrogenase enzyme}$$

The activity of cytochrome oxidase was determined on the same stages. In each case the enzyme activity was measured on tissue homogenates in a final concentration of 1:10,000. The insects were homogenized in 0.03 M phosphate buffer adjusted to a pH of 7.4. Cytochrome oxidase was measured spectrophotometrically by the method of Cooperstein and Lazarow (1951). Its activity is expressed as $\Delta\log [\text{CyFe}^{++}]/\text{min.}$

OBSERVATIONS

The changes in activities of various dehydrogenase enzymes during the metamorphosis of the Mediterranean flour moth are given in Table 1. Each value represents a minimum of six determinations, each requiring 3 to 7 insects.

Six dehydrogenases were U-shaped in activity during metamorphosis. They are alpha-glycerophosphate I and II (GPD I and II), malic, isocitric and succinic dehydrogenases and the malic enzyme. In all cases the activity in the newly emerged adult exceeded that of the larva, the greatest difference being found for malic dehydrogenase and the least being for alpha-glycerophosphate I dehydrogenase and the malic enzyme. In addition the low point of activity always occurred during the early pupal stage. Greatest activity was shown by malic dehydrogenase; moderate activity by alpha-glycerophosphate I (requires DPN) and isocitric dehydrogenases and the malic enzyme, and the lowest by succinic dehydrogenase. Alcohol dehydrogen-

Stage	DEHYDROGENASE						no coenzyme required				
	coenzyme: DPN						TPN				
	Alcohol	Glucose	GPD I	Glutamic	Lactic I	Malic	Iso-Citric	Malic enzyme	GPD II	Lactic II	Succinic
DEHYDROGENASE											
Larva	0.008	0.001	0.072	0.012	0.034	0.215	0.064	0.040	0.011	0.005	0.011
Prepupa	0.038	0.001	0.030	0.009	0.122	0.062	0.014	0.012	0.004	0.002	0.002
Pupa, 1 day	0.032	0.006	0.024	0.002	0.009	0.075	0.037	0.020	0.003	0.001	0.002
Pupa, 2 day	0.032	0.004	0.022	0.001	0.008	0.080	0.032	0.016	0.003	0.001	0.002
Pupa, 3 day	0.025	0.004	0.020	0.002	0.007	0.067	0.015	0.018	0.002	0.001	0.001
Pupa, 4 day	0.032	0.002	0.020	0.003	0.007	0.074	0.036	0.021	0.001	0.002	0.001
Pupa, 5 day	0.042	0.004	0.023	0.003	0.009	0.072	0.035	0.024	0.005	0.001	0.003
Pupa, 6 day	0.042	0.002	0.023	0.002	0.010	0.158	0.055	0.030	0.005	0.001	0.009
Pupa, 7 day	0.026	0.002	0.032	0.003	0.008	0.247	0.052	0.022	0.009	0.001	0.010
Pupa, 8 day	0.028	0.003	0.041	0.003	0.007	0.439	0.053	0.023	0.025	0.002	0.021
Adult, newly emerged	0.074	0.006	0.081	0.005	0.007	0.991	0.084	0.049	0.033	0.002	0.035

TABLE 1.

Dehydrogenase activity during the metamorphosis of the Mediterranean flour moth, *Ephesia kühniella*. Activity is expressed as 1/time in minutes for 90 per cent decoloration of methylene blue. The figures listed were obtained by subtracting the value of the control tube from that of the experimental tube. Readings made at 30° C. (GPD is alpha-glycerophosphate dehydrogenase).

ase showed an irregular course of activity, being low in the larva, moderately high in the prepupa and pupal period and reaching a peak in the adult. Lactic I dehydrogenase (requires DPN) exhibited low activity while lactic II dehydrogenase activity was found in the larva and prepupa only. Glucose dehydrogenase activity was absent in the larva and prepupa and low during the rest of metamorphosis. Glutamic dehydrogenase, on the other hand, showed activity in the larva and prepupa, but was absent or showed only slight activity in the pupal and adult stages.

Cytochrome oxidase was also U-shaped in activity during metamorphosis (Table 2). Activity in the larva was high at

Stage	Enzyme Activity $\Delta\log [\text{CyFe}^{++}]/\text{min.}$		
	Minimum	Maximum	Average
Larva	0.033	0.085	0.065
Prepupa	0.022	0.067	0.036
Pupa, 1 day	0.009	0.022	0.015
Pupa, 2 day	0.005	0.014	0.010
Pupa, 3 day	0.009	0.018	0.012
Pupa, 4 day	0.006	0.013	0.009
Pupa, 5 day	0.015	0.038	0.025
Pupa, 6 day	0.044	0.080	0.065
Pupa, 7 day	0.042	0.093	0.068
Pupa, 8 day	0.092	0.127	0.110
Adult, newly emerged	0.083	0.178	0.134

TABLE 2.

Cytochrome oxidase activity during the metamorphosis of *Ephestia kühniella*. Enzyme activity is expressed as $\Delta\log [\text{CyFe}^{++}]/\text{min.}$ Homogenate concentration is 1:10,000.

0.065, decreasing to 0.009 in the 4-day pupa, and increasing rapidly during the remainder of the pupal stage reaching 0.134 in the adult.

DISCUSSION

These results and those of Agrell (1949) with the blow fly, *C. erythrocephala*, Ludwig and Barsa (1958, 1959) with the mealworm and the house fly, show that malic and succinic dehydrogenases and the malic enzyme consistently show U-shaped activities during metamorphosis in all insects in which they have been studied. They are involved in the oxidation-reduction

reactions of the tricarboxylic acid cycle. Malic dehydrogenase accounted for a very large portion of total activity, being the most active enzyme during the metamorphosis of the flour moth. In the mealworm and the house fly (Ludwig and Barsa 1958, 1959) it showed high activity but was not always the most active enzyme throughout metamorphosis, its activity being exceeded in some stages by that of isocitric dehydrogenase. Malic enzyme was less active in the flour moth than in either the mealworm or house fly. Both malic dehydrogenase and the malic enzyme catalyze the oxidation of *l*-malate, the end product with malic dehydrogenase being oxaloacetate; whereas with the malic enzyme, they are pyruvate and CO₂. In this latter reaction there is no evidence that oxaloacetate is an intermediate (Veiga Salles and Ochoa 1950). Faulkner (1956) has shown in insect blood that the oxidation of malate to pyruvate by the malic enzyme can be reversed.

The low activity of lactic I and II dehydrogenases is in agreement with the results of Ludwig and Barsa (1959) but not with Agrell (1949) who indicated that lactic dehydrogenase activity was moderately high during the metamorphosis of the blow fly. The low activity for total lactic dehydrogenase combined with the high rates of malic dehydrogenase and the malic enzyme lend support to the hypothesis of Ludwig and Barsa (1958) that in insects lactate does not accumulate, but rather that pyruvate is reduced to malate which is then oxidized to oxaloacetate.

The observation that the activity of alpha-glycerophosphate dehydrogenase I was greater than that of alpha-glycerophosphate dehydrogenase II in the flour moth agrees with that of Zebe and McShan (1957) with various species of insects. These authors suggest that the oxidation-reduction of alpha-glycerophosphate, although relatively unimportant in vertebrates, must be very important in insects as indicated by the higher activity of alpha-glycerophosphate I dehydrogenase in insects. In addition, the low rate of lactic and high rate of alpha-glycerophosphate I dehydrogenases found in the flour moth lends support to the work of Zebe and McShan (1957) who showed that the activities of these two enzymes were related. They found that in insect flight muscles, the activity of lactic dehydrogenase was low and alpha-glycerophosphate dehydrogenase was high, whereas in some special cases of leg muscle the related activities

were exactly reversed. They concluded that in different muscles, at least to a degree, one enzyme might take the place of the other.

Isocitric dehydrogenase activity in the flour moth was not only considerably lower than that found in both the mealworm and house fly (Ludwig and Barsa 1958, 1959), but the course of the activity differed. Whereas in the flour moth and the blow fly (Agrell 1949) its activity was U-shaped, with the mealworm and house fly it decreased steadily throughout metamorphosis. This enzyme in the presence of TPN and Mn⁺⁺ catalyzes the oxidation of isocitrate through oxaloacetate to alpha-ketoglutarate. The activity of succinic dehydrogenase was uniformly low in all insects studied; and in fact was the lowest of all enzymes whose activity is U-shaped. This observation suggests that it could be the rate-limiting factor in determining the U-shaped respiratory curve.

The observation that cytochrome oxidase activity follows a U-shaped course during metamorphosis of the flour moth is in agreement with that of Wolsky (1938), Williams (1950), Sacktor (1951) and Ludwig (1953) with the fruit fly, *D. melanogaster*, the moth, *Platysamia cecropia*, the house fly, *M. domestica*, and the Japanese beetle, *P. japonica*, respectively. However, it is not in accord with the findings of Ito (1955) with the silk worm, or of Ludwig and Barsa (1956b) with the mealworm. Ito (1955) concluded that, whereas cytochrome oxidase activity shows a curve similar to that of oxygen uptake after the middle of the pupal period, it does not parallel oxygen uptake during the early part of this stage. Thus, while cytochrome oxidase may be a terminal oxidase, it is not the rate-limiting enzyme throughout the entire course of metamorphosis in all insects studied.

SUMMARY

A study was made of the activities of dehydrogenase enzymes during the metamorphosis of the Mediterranean flour moth using the Thunberg technique. The activity of cytochrome oxidase during this same period was determined spectrophotometrically.

Six dehydrogenase enzymes exhibited U-shaped activity curves. They are alpha-glycerophosphate I and II, malic, isocitric and succinic dehydrogenases and the malic enzyme. The most active enzyme of this group was malic dehydrogenase and the least active was succinic dehydrogenase. Moderate activity was shown

by alpha-glycerophosphate I and isocitric dehydrogenases and the malic enzyme. Alpha-glycerophosphate II dehydrogenase showed low activity.

The activities of lactic I and II, glucose and glutamic dehydrogenases were low or negligible, whereas that of alcohol dehydrogenase was irregular.

The low activity rate for total lactic dehydrogenase combined with the high rate of malic dehydrogenase and the malic enzyme lends support to the hypothesis that lactate does not accumulate in insects, but rather that pyruvate is reduced to malate which is then oxidized to oxaloacetate. Additionally, the low rate of lactic and high rate of alpha-glycerophosphate I dehydrogenases lend support to work indicating that the activities of these two enzymes are related in insect muscles and this relationship may be reversed in certain muscles.

With the exception of alpha-glycerophosphate I and II, the results indicate that the dehydrogenases showing U-shaped activity curves are involved in oxidation-reduction reactions of the tricarboxylic acid cycle. The rate of succinic dehydrogenase being the lowest of those exhibiting U-shaped activity curves, adds support to previous work indicating that this enzyme may be a rate-limiting factor in determining the U-shaped respiratory curve.

The activity of cytochrome oxidase was also found to be U-shaped during metamorphosis.

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THE MALE GENITALIA AND TERMINAL
SEGMENTS OF SOME MEMBERS OF
THE GENUS *POLYERGUS*
(HYMENOPTERA: FORMICIDAE)

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ABSTRACT

The male genitalic valves and terminal segments are described for *P. lucidus* Mayr, *P. rufescens breviceps* Emery, *P. rufescens bicolor* Wasmann, and *P. rufescens umbratus* Wheeler. These structures show differences which are distinctive for each of the species and subspecies studied. The configuration of the subgenital plate together with the middle valve can be used as a means of identification for these species and subspecies of *Polyergus*.

The increase in the number of studies which seek generic and specific differences in the male genitalia and terminal segments of ants gives evidence to the growing use of these structures as criteria for classification. Emery (1895) separated the doryline from the ponerine ants on the basis of the position of the genitalia. In 1896, he classified additional formicid subfamilies, again using the position of the genitalia as a criterion. Since that time, numerous observations have been made of the male genitalia and terminal gastral segments, which have furthered classification. Some of these studies have been concerned with the shapes and positions of the terminal segments and genitalic valves on the intact specimens (Santschi, 1907, 1908; Emery, 1910, 1925). Other studies have shifted the emphasis from position to structure of the genitalic valves and terminal segments dissected from the specimens (Wheeler, 1934; Clausen, 1938; Weber, 1947, 1948, 1950). More recent studies have extended the use of dissected genitalia and the surrounding segments (Borgmeier, 1950, 1955; Bernard, 1956; Krafchick, 1959). In general, differences have been reported which are significant. However, Buren (1958), in connection with his study of the genus *Crematogaster*, states that the differences in the genitalia are so slight as to be useless for species diagnosis.

In this paper, the genitalic valves and the terminal segments of the two species and three subspecies of the genus *Polyergus*, as it is presently constituted, are described. Creighton (1950) discusses the difficulties in classifying the members of this genus. When considering *bicolor* specifically, he states, "I have retained *bicolor* as an eastern race of *rufescens* although I am aware that it is often difficult to separate *bicolor* from *breviceps*. There seems to be nothing except color by which the two races may be distinguished." This study reveals differences which can be used in the classification of these forms.

MATERIALS AND METHODS

The males of *Polyergus lucidus* Mayr were collected from nests in Bergen County, New Jersey during July 1959 by Stanley Forsythe, a Fordham College student. The *P. rufescens breviceps* Emery specimens were collected at Ute Park, New Mexico, July 1952 by Dr. Arthur C. Cole of the University of Tennessee, Knoxville, Tenn. The *lucidus* and *breviceps* specimens were preserved in 70 percent ethyl alcohol. Two dry, pinned specimens, a *P. rufescens bicolor* Wasmann and a *P. rufescens umbratus* Wheeler, were provided by Dr. William S. Creighton from his collection. The former he collected during September 1933 in the Black Hills of South Dakota and the latter during August 1934 in the Uinta Mountains of Utah. The authors are grateful for the specimens which made this study possible.

The posterior portions of the gasters of the dried, pinned specimens were carefully removed and placed in 30 percent ethyl alcohol for four days in order to soften them for the dissection of the segments. At intervals, they were subjected to gentle heating. The posterior ends of the gasters of the preserved specimens were removed under 70 percent ethyl alcohol. Small, round depressions were prepared in a layer of paraffin on the bottom of a Syracuse watch glass. Into these depressions a few drops of a solution of glycerin and 95 percent ethyl alcohol was placed; the glycerin-alcohol solution was in the proportion, three to one. Each of the severed, terminal portions was transferred to a depression. The final separation of the genitalic valves and terminal segments was accomplished here. The valves and segments were next dehydrated in 95 percent ethyl alcohol and mounted in diaphane.

The use of the glycerin-alcohol solution as a dissection medium for these structures has two advantages. Its viscosity tends to hold the segments in position so that, once separated, the minute valves and segments do not drift out of the dissecting field. Thus, they are more readily located for removal and mounting. Also, this solution, when used in small amounts, does not evaporate at an appreciable rate.

The terminology used in this study has been previously employed (Forbes, 1952). A Bausch and Lomb Tri-simplex micro-projector was used in preparing the drawings.

OBSERVATIONS

The males of the *Polyergus* species and subspecies studied show some variation in size. The average length of ten *P. lucidus* males was 8.5 mm., that of three *P. rufescens breviceps* was 5.8 mm., while the *P. rufescens umbratus* specimen measured 6.7 mm. and *P. rufescens bicolor* 6.8 mm.

The genitalia projects ventrally from the posterior end of the male gaster. It is inserted between the ninth and the tenth terga and the ninth sternum or subgenital plate and consists of three pairs of valves held together at their proximal ends by the basal ring. This position and arrangement correspond to the typical pattern previously reported for other members of the subfamily Formicinae (Clausen, 1938; Snodgrass, 1941; Forbes, 1952; Krafchick, 1959).

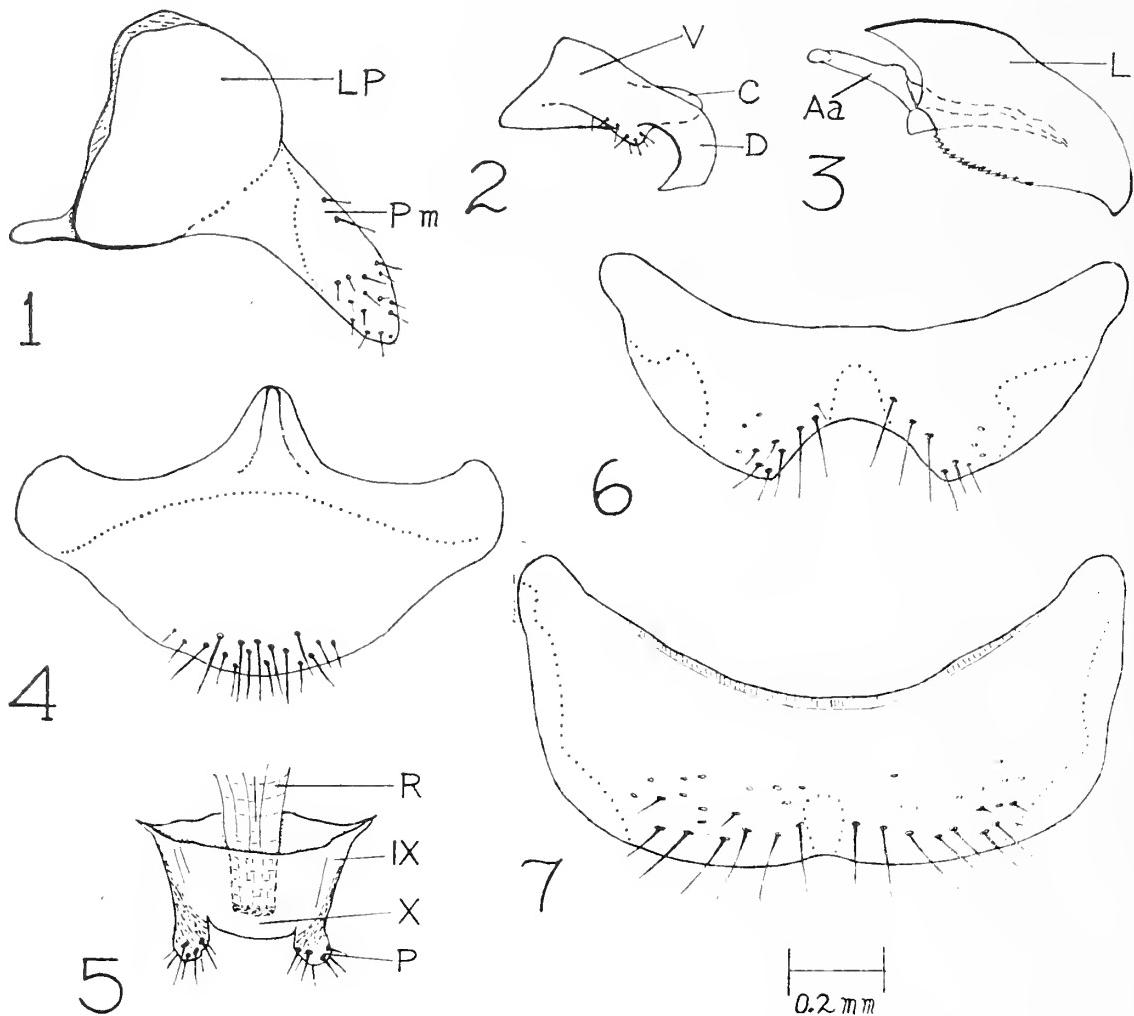
The ninth and tenth terga, the dorsal terminal segments, (fig. 5) are alike in these species and subspecies; perhaps, there are very slight variations in the lengths and shapes of the pygostyles. These segments are unsclerotized except for the lateral margins of the ninth tergum and the pygostyles, which are sclerotized.

The basal ring or lamina annularis, likewise, reveals no differences in shape or sclerotization. It is moderately sclerotized throughout and more heavily sclerotized laterally.

The outer valves consist of a large, laterally convex basal segment, the lamina parameralis, and a narrow, finger-like, distal extension, the paramere (fig. 1). These valves are moderately sclerotized with the exception of a region at the base of the paramere. The position of this unsclerotized region is about the same in the outer valves of all the forms, but its shape varies. The anterior margin of each lamina parameralis is thickened

and more heavily sclerotized. In the three *rufescens* subspecies a small, arciform swelling is present at the base of the paramere on its dorsal or posterior surface; this is lacking on the paramere of *lucidus*. In the figures, the unsclerotized region at the base of the paramere is the area enclosed by the dots. The variation in the shapes of the outer valves is shown in figures 1, 8, 12, and 16.

The middle valves are composed of a basal portion, the lamina



EXPLANATION OF PLATE I

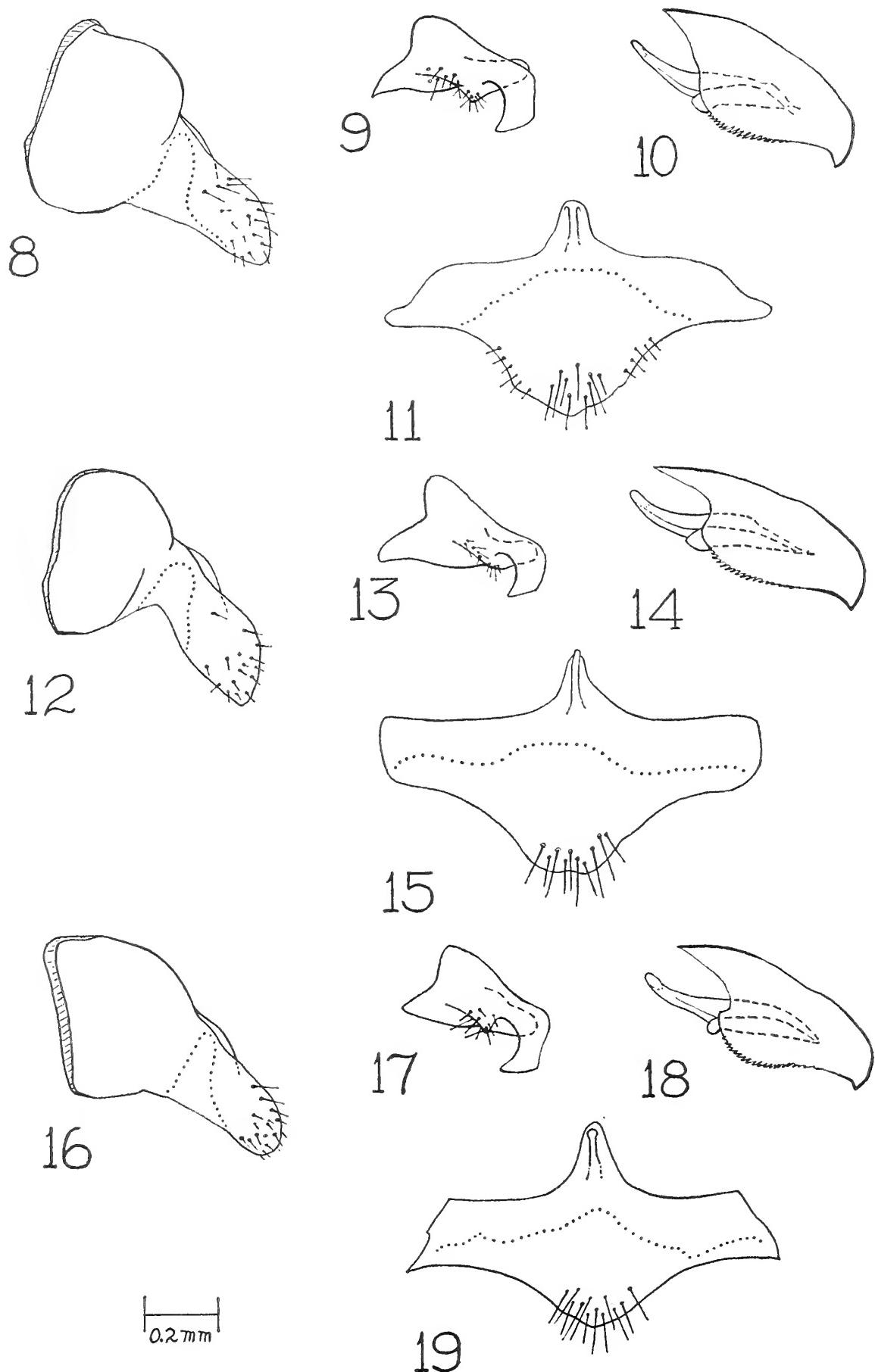
Figs. 1-5, *Polyergus lucidus*. FIG. 1, Lateral view of outer genitalic valve. FIG. 2, Median view of middle genitalic valve. FIG. 3, Median view of inner genitalic valve. FIG. 4, Ventral view of subgenital plate, the ninth sternum. FIG. 5, Dorsal view of ninth and tenth terga. FIG. 6, Ventral view of eighth sternum of *P. rufescens breviceps*. FIG. 7, Ventral view of eighth sternum of *P. lucidus*. All figures drawn to the scale indicated. Abbreviations: Aa, Aedeagal apodeme; C, Cuspis volsellaris; D, Digitus volsellaris; L, Lamina aedeagalis; LP, Lamina parameralis; P, Pygostyle; Pm, Paramere; R, Rectum; V, Lamina volsellaris; IX, Ninth tergum; X, Tenth tergum.

volsellaris, from which a lateral lobe, the cuspis volsellaris, and a median lobe, the digitus volsellaris, extend distally. The cuspis is the shorter lobe, and its rounded end is directed dorsally or posteriorly. The digitus extends beyond the cuspis and then bends ventrally to form a hook-like projection. Small sensory pegs, the sensilla basiconica, are found on the apposing surfaces of the cuspis and digitus. This middle valve is the most strongly sclerotized of the genitalia and of the terminal segments. It is dark brown or almost black in color, while the other valves and segments are light brown or medium brown in color. The shape of the digitus is significant since it varies for each form in length and curvature (figs. 2, 9, 13, and 17). Further, the angle which the cuspis forms with the valve varies; this may be important.

The inner pair of valves consists of two laterally compressed plates, the laminae aedeagales. These are united dorsally by the weakly sclerotized spatha. Each lamina aedeagalis tapers distally to end in a slightly recurved hook, and its ventral surface or lower edge is partially serrated. These valves are moderately sclerotized. A more strongly, sclerotized aedeagal apodeme is found on the lateral wall and extends anterolaterally. No pronounced differences were observed in these valves (figs. 3, 10, 14, and 18).

The subgenital plate or ninth sternum covers the ventral, anterior portions of the genitalia. It is moderately sclerotized only in its posterior regions. The anterior portions are weakly sclerotized. In the figures, these are the regions above the dotted lines. The anterior, median projections of these segments in *breviceps* and *bicolor* are slightly more heavily sclerotized than in *umbratus* and *lucidus*. The shape of this segment differs markedly for each of the forms studied (figs. 4, 11, 15, and 19).

The eighth sternum, by its position, covers the anterior portion of the subgenital plate. The difference in the shape of the eighth sternum in *lucidus* and *breviceps* is shown in figures 7 and 6; this segment was not available from *umbratus* and *bicolor*. It is moderately sclerotized except on the lateral and ventral median portions, which are weakly sclerotized. In the figures the weakly sclerotized areas are bounded by the dotted lines. In *lucidus* the posterior, median, weakly sclerotized area may be larger in extent than is illustrated. The anterior margin is heavily sclerotized in *lucidus*.



DISCUSSION

The genitalic valves and subgenital plates of all the forms studied show some variations. The greatest variation observed was in the length and curvature of the digitus of the middle valves. This study found only minor variations in the inner valves. However, the angle which the lateral apodeme forms with the inner valves might be a differentiating feature; additional information from more species is needed to resolve this. In future studies of the terminal segments of male ants, the eighth sternum should be examined for each species and subspecies. This structure was examined for *lucidus* and *breviceps*, and a variation in shape was noted. Since the subgenital plate differed in all the forms examined, the configuration of this segment may be a highly important differentiating aid.

Only twice before have studies been made of the genitalic valves and terminal segments of species of *Polyergus*. Clausen (1938) examined and figured the genitalic valves, the ninth and tenth terga, and the subgenital plate of the Swiss species, *P. rufescens*. The segments of this species are similar in shape to those in this study. The outer valve, likewise, has an arciform swelling at the base of the paramere. The configurations of the valves and segments of *P. rufescens* place it close to *P. rufescens breviceps*; however, differences do exist which separate it from the American subspecies, *breviceps*, *bicolor*, and *umbratus*.

Krafchick (1959) has figured the genitalia and ninth sternum of *P. lucidus*, and the observations made in this study confirm his. He has also figured the ninth sternum of a specimen identified as *P. rufescens breviceps* (Pl. XII, 9B). This study does not confirm Krafchick's figure; in fact, his figure does not resemble any subgenital plate reported in this paper. There might

EXPLANATION OF PLATE II

The genitalic valves and subgenital plates of the subspecies of *Polyergus rufescens*. All outer valves are viewed laterally, the middle and inner valves medially, the subgenital plates ventrally. All figures drawn to the scale indicated. FIGS. 8-11, *P. rufescens breviceps*. FIG. 8, Outer valve. FIG. 9, Middle valve. FIG. 10, Inner valve. FIG. 11, Subgenital plate. FIGS. 12-15, *P. rufescens bicolor*. FIG. 12, Outer valve. FIG. 13, Middle valve. FIG. 14, Inner valve. FIG. 15, Subgenital plate. FIGS. 16-19, *P. rufescens umbratus*. FIG. 16, Outer valve. FIG. 17, Middle valve. FIG. 18, Inner valve. FIG. 19, Subgenital plate.

be a question of determination of the specimens since Kraftchick reports that his specimen was collected in Illinois, whereas Creighton (1950) places the distribution of this subspecies in the Rocky Mountain region. Another explanation might be that *breviceps* is a complex.

SUMMARY

The genitalic valves and terminal segments of *Polyergus lucidus* Mayr, *P. rufescens breviceps* Emery, *P. rufescens bicolor* Wasmann, and *P. rufescens umbratus* Wheeler are described and figured. The position and arrangement of the genitalia and terminal segments correspond to the typical pattern previously reported for other members of the Formicinae.

The ninth and tenth terga of the terminal segments and the basal ring of the genitalia show no variations. The inner genitalic valves show very minor variations, while the outer valves show some differences in shape.

The middle valves are the most heavily sclerotized, and the length and curvature of the digitus is distinctive. The moderately sclerotized, subgenital plate differs markedly in shape. Together, the configuration of the genital plate and the middle valve can be used as a means of identification.

Comparisons are made with the genitalia and terminal segments of the few other reported species of *Polyergus*. This study reveals that distinctive differences in the male genitalia and terminal segments can serve as useful adjuncts in classification for members of this genus.

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A DIMORPHIC SPECIES OF ACTALETES (COLLEMBOLA)

BY PETER F. BELLINGER*

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RECEIVED FOR PUBLICATION NOVEMBER 30, 1961

ABSTRACT

Males of *A. calcarius* (Actaletidae), Jamaica, have distinctive leg appendages. The other known sp. of this littoral family is European.

Actaletes calcarius new species

Facies (fig. 1) typical of the family, i.e. isotomoid but with highly modified abdominal segmentation and extreme posterior displacement of the furcula. Color in alcohol dark gray-brown. Length of largest specimens (position as in fig. 1) slightly over 1 mm. Body covered with numerous short setae, all simple except as noted below.

Antennae slightly shorter than head (in smallest specimens) to more than three times head length (large males). First segment always the shortest and thickest; segments increase in length distally in smallest specimens, but the second and third segments are much the longest in adults. First three segments subcylindrical, fourth segment faintly curved or S-shaped. Most setae shorter than antennal width, but a few much longer setae on terminal segments, especially in large males (fig. 2). A few differentiated setae in apical half of fourth segment: some short, straight, and blunt, some apically curved and tapering. Apical seta basally expanded. Sense organ of third segment has two blunt pegs in a common groove; no differentiated guard setae visible. A flat conical lobe, shorter than most setae, projects from the dorsal apex of the second segment over the base of the third segment.

Head hypognathous. Antennal bases differentiated, without setae. Post-antennal organ oval, of isotomid type, somewhat smaller than anterior eye. Eight eyes on each side, the posterior three in a slightly separated group; medial eye in each group about two-thirds the size of the others.

First thoracic segment reduced dorsally, without setae. Second tergite slightly longer than third.

Leg segmentation normal. Unguis (fig. 4) has weak inner and lateral teeth at about half its length. Unguiculus tapering, with a large, sharply angled inner lobe. A very thin, tapering, scale-like projection extends above the unguis from just before its base nearly to the tip (apparently this is easily detached). Setae numerous, mostly shorter than diameter

* The collections on which this note is based were made with the assistance of a grant from the Nuffield Foundation.

of leg segments. In males, on the first pair of legs the tibiotarsus bears two or three heavy spines on its inner surface, longer than the segment width and over twice the thickness of the ordinary setae; the femur bears two to four somewhat weaker spines on its inner surface. Also in males, the tibiotarsus of the third pair of legs bears a leaf-like projection with three long setae (figs. 3, 5).

Abdominal segmentation (see fig. 1) highly modified; last three segments fused, and dorsal portion of last two visible only on posterior face of abdomen. The furcula articulates with two dorsolateral, rod-shaped, tapering sclerotizations extending forward the length of the fourth abdominal segment, and two ventral sclerotizations of about the same length but thicker and knobbed at the anterior end.

Rami of tenaculum have four teeth. Corpus has five setae, the three distal setae being enlarged.

Manubrium has numerous setae, but basal half of anterior surface and median area on both surfaces bare. Dentes (fig. 6) have numerous setae, those on inner and outer surfaces being especially long (up to more than twice the width of the dens). On the dorsal surface are a number of blunt spines: one near base, a pair at about one-third the length, and two rows in the distal half; commonly seven in the inner row and four in the outer. Mucro (fig. 7) tridentate; apex weakly upturned; anteapical tooth in line, with posterior and two anterior lamellae; basal tooth displaced laterally, with anterior, posterior, and inner lamellae. A mucronal seta on the external surface basally.

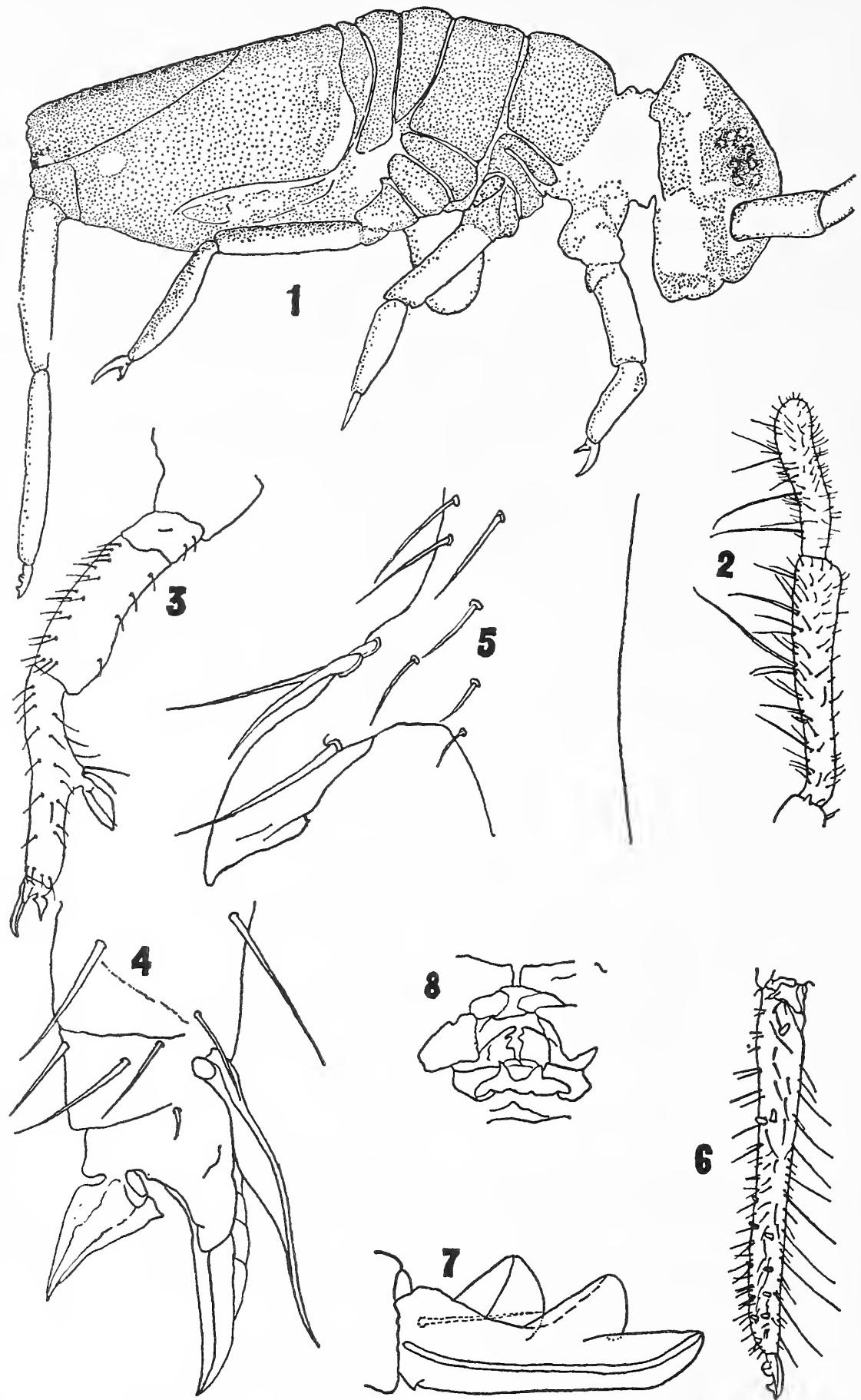
Genital opening on extreme posterior surface of abdomen. Female opening a transverse slit, without associated setae; male opening (fig. 8) complex and difficult to interpret.

HOLOTYPE male and ALLOTYPE female Lazaretto Beach, St. Catherine Parish, Jamaica, on wave-splashed vertical limestone cliff at water's edge, 21 June 1956.

PARATYPES 7 males, 40 females, and 35 immature specimens of uncertain sex: same locality, 13, 18, 21 June and 4, 6, 7 July 1956.

The holotype and allotype will be deposited in the British Museum (Natural History). Paratypes will be deposited in the Museum of Comparative Zoology, Cambridge, Mass., and in the Institute of Jamaica, Kingston; others are in the author's collection.

I have not been able to obtain material of the only other known species of Actaletidae, *A. neptuni* Giard, for comparison. Judging from the figures given by Willem, 1900, 1901, and Strenzke, 1955, the new species differs from *A. neptuni* unequivocally in having the anteapical and basal mucronal teeth in tandem instead of side by side. Other apparent differences are



the presence of spines on the dentes, and the conspicuous sexual dimorphism; it is possible, if unlikely, that these characters are present in the European species but have been overlooked.

Measurements of head length on all available specimens show a number of discrete size classes, suggesting that there are three or four juvenile instars and that the distinctive male characteristics of the first and third legs appear abruptly in the following instar, probably together with sexual maturity. Collembola of course have imaginal molts, and the later adult instars evidently are larger and have an increasing ratio of antennal length to head length. Large males can be recognized at once by the very elongate antennae, and even in the smallest recognizable male the ratio antenna/head is over 2:1, while it never attains this value in the largest females.

A. neptuni is known only from the northern coast of France and Belgium; the occurrence of the new species in the Caribbean is most unexpected. However, the littoral Collembola of most parts of the world are poorly known, and the family may yet turn out to be more widely distributed.

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EXPLANATION OF PLATE

- FIG. 1. Adult female, entire, $\times 50$.
- FIG. 2. Third and fourth antennal segments of male, dorsal, $\times 100$.
- FIG. 3. Distal part of third leg, adult male, $\times 100$.
- FIG. 4. Third unguis, $\times 600$.
- FIG. 5. Projection on third tibiotarsus of adult male, $\times 600$.
- FIG. 6. Dens and mucro, dorsolateral, $\times 100$.
- FIG. 7. Mucro, internal surface, $\times 600$.
- FIG. 8. Male genital area, $\times 225$.

BOOK REVIEW

BUTTERFLIES OF THE AMERICAN TROPICS, THE GENUS ANAEA (LEPIDOPTERA: NYMPHALIDAE). William Phillip Comstock. Illustrated with colored plates and drawings by Misses Majorie Statham, Dorothy Fitchew, Alice Gray and Dorothy K. Barlow. Printed for the American Museum of Natural History by W. S. Cowell, Ltd., Ipswich, England, 214 pp. + xiv., price \$25.00.

It is difficult to write a review of a Monograph such as this. William P. Comstock has created a lasting monument to the value of care and meticulous detail in the writing of a scientific work. The book is illustrated with 30 colored plates from drawings by Miss Majorie Statham and Miss Dorothy Fitchew and one may well marvel at the beauty and accuracy of their work. Miss Alice Gray drew the special diagrams and maps; the drawings of the genitalia are by Mrs. Dorothea K. Barlow of the American Museum of Natural History staff.

Dr. Mont A. Cazier who was Chairman of the Department of Insects and Spiders at the time this work was completed in February, 1949, the late Frank Johnson who sponsored the project, and the Trustees of the Museum showed great discernment in supporting the publication of this volume which, unfortunately, Mr. Comstock did not live to see.

Dr. Frederick H. Rindge, Associate Curator of the Department of Entomology (as it is now designated) has done invaluable editing and Dr. David Rockefeller is to be thanked for having furnished financial support in addition to that obtained from the National Science Foundation.

This is a magnificent publication of which all those connected with it should indeed be proud. Were Mr. Comstock here today to see the results of his long devotion to his subject, he would be gratified. This volume will stand as a posthumous honor and an enduring tribute to him.

Your reviewer has had the privilege of having worked in close association with Mr. Comstock over a period of many years.

E. IRVING HUNTINGTON
RESEARCH ASSOCIATE,
DEPT. OF ENTOMOLOGY,
AMER. MUS. NAT. HIST.

BOOK REVIEW

THE CATERPILLAR AND THE BUTTERFLY. Robert E. Snodgrass. Smithsonian Miscellaneous Series, Volume 143, Number 9. 51 pp. (Pub. No. 4472). Smithsonian Institution, Washington, D. C. November, 1961.

This delightful booklet is in one respect a companion piece to Dr. Snodgrass' "The Anatomical Life of the Mosquito" in the fact that it presents a remarkably thorough review of the literature on anatomy and development of lepidopterous insects. This is done, as might be expected, in a very pleasing and readable style, and is entirely comprehensible to anyone at all interested in the Lepidoptera. It is also a serious treatise on morphology, and provides both a unifying theory of lepidopterist evolution and a wealth of factual material for the specialist.

Dr. Snodgrass' central theory is the concept that the "adult (lepidopterous) insect is responsible for the structure of the larva";—in an evolutionary sense. This responsibility, he shows, had its origin in the evolutionary trend in mouthpart structure of the adult ancestors of present-day moths and butterflies, which resulted in the evolution of the familiar coiled proboscis of the Lepidoptera. Thus the adult insect became limited in its feeding to the nectar of blossoms, a fact demonstrated by the absence in these insects of any enzymes other than invertase. "Though nectar was formerly a favorite drink of the gods, it must be a very inadequate diet even for a moth or a butterfly. The female at least needs proteins for the production of yolk-filled eggs. Hence it should be the duty of the caterpillar to store up reserves in its body to supplement its diet in its own adult stage." Snodgrass next proceeds to show how the immature insect has been structurally modified to equip it to meet this obligation, and the result is the typical modern caterpillar with which we are all familiar.

A fascinating study of caterpillar specialities follows, including an easily-comprehended description of that amazingly complex activity, the locomotion of caterpillars. The metamorphosis of the Lepidoptera is treated in the vein of Dr. Snodgrass' earlier writings on this subject. The view that the larva represents a free-living stage of the embryo is logically examined and dismissed as something akin to science fiction. There is also a brief review of the more recent literature on hormones and metamorphosis.—J. B. SCHMITT

NEW BOOKS

Insect Polymorphism (Edited for the Royal Entomological Society by J. S. Kennedy). Published December 1961, Super Royal 8 vo, viii 116 pp. Price: os.od. plus 1 s. od extra for postage and packing. This publication contains the first Symposium held by the Royal Entomological Society in London on September 21st and 22nd, 1961.

Insect Fact and Folklore, Lucy W. Clausen. Paperback edition published by Collier Books, Inc., 1962, 222 pp., black and white illustrations. Price: \$.95.

Supplement to the Annotated, Subject-heading Bibliography of Termites, 1955 to 1960, Thomas E. Snodgrass. Published by the Smithsonian Institution, December 29, 1961, 137 pp. Smithsonian Publication 4463.

The Forest, LIFE Nature Library Series, Peter Farb and the Editors of Life. Published by Time Incorporated, N. Y., 1961, 192 pp. profusely illustrated with color plates, black and white photographs and diagrams. Price: \$3.95.

Les Morpho—D'Amérique du sud et D'Amérique centrale (morphologie, historique, systematique), E. Le Moult and P. Réal. Published by Les Editions du Cabinet Entomologique, Paris. Two volumes, in quarto. Price: in one payment—530 NF; in two payments—750 NF. This publication contains 300 illustrations including 400 species, 165 subspecies, 90 seasonal forms and 7 new species.

A NEW GENUS AND SPECIES OF DISCOCEPHALINE PENTATOMID (HETEROPTERA: PENTATOMIDAE)

BY HERBERT RUCKES¹

RECEIVED FOR PUBLICATION FEBRUARY 12, 1962

ABSTRACT

Describes **Parantiteuchus hemitholus** from French Guiana as a new genus distinct from *Antiteuchus* Dallas by virtue of the longer head, sinuate anterolateral pronotal margins, gibbous scutellum, crenulated abdominal margin, and ramosc veins in the hemelytral membranes.

While sorting an old accumulation of miscellaneous Neotropical Heteroptera which have been residual in the collections of the American Museum for a number of years, the following interesting specimen was discovered. It is sufficiently distinctive to warrant description.

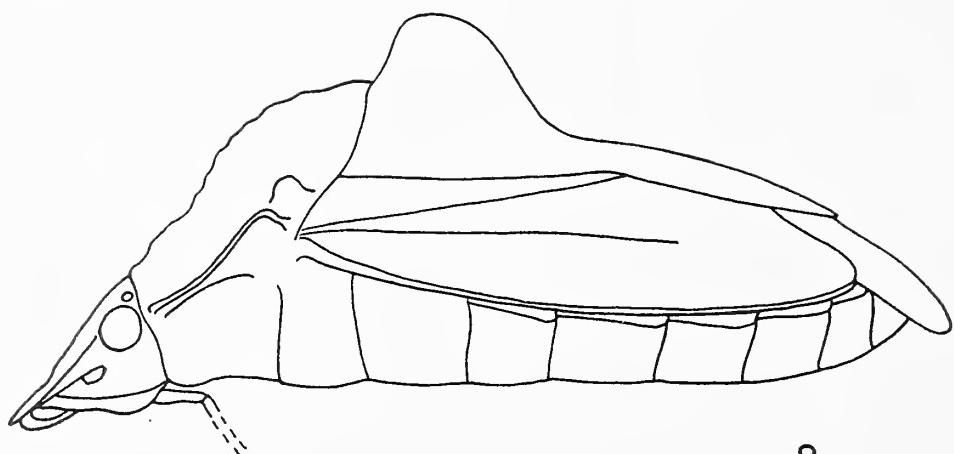
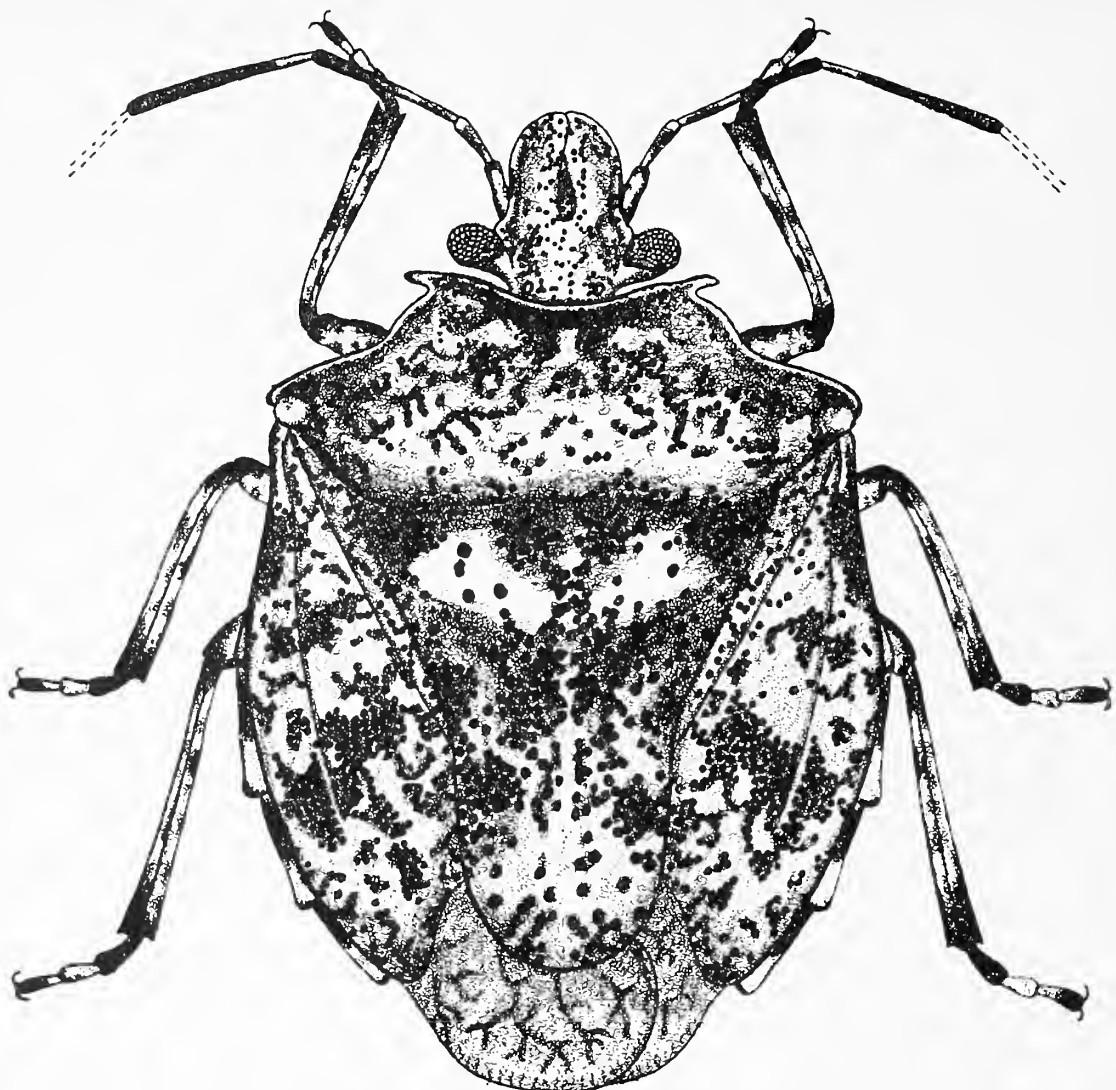
Parantiteuchus, new genus (Figures 1 and 2)

Ovate, large, 15.0 mm. long; strongly convex above, much less so beneath; glossy, upper surface rough, coarsely punctured and pitted; head and anterior portion of the pronotum decidedly declivous.

Head elongate oval, not quite half again as long as wide between the eyes; margins very obscurely reflexed near the base and obtusely sinuate; from there onward subparallel, the apex entire and evenly rounded; ocelli twice as far apart as distant from the eyes; surface flat. Antennae five-segmented, reaching beyond the middle of the scutellum, segment I not exceeding the apex of the head, segments I and II subequal, segment II much shorter than segment III which is subequal to segment IV; segment V missing.

Pronotum subhexagonal, about two and one-third times as wide across the humeri as long medially; the anterior margin a little wider than the head through the eyes, somewhat thickened and slightly elevated centrally followed by a short, broad transverse groove behind the central excavation, then truncate behind the eyes and terminating laterally in a prominent tubercle; anterolateral margins very narrowly carinate (the carina ending abruptly just before the humerus), subreflexed, and distinctly angularly sinuate at their middles; cicatrices and humeri tumid, the latter sub-prominent, the humeral angles subrectilinear, rounded. Scutellum stout,

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FIG. 1: *Parantiteuchus hemitholus* new genus, new species.

FIG. 2: Left profile view of the body minus antennae and legs.

about one-third longer than wide at the base, the frena surpassing the middle, the postfrenal margins parallel, the apex rather broadly rounded, reaching the base of the seventh abdominal tergite (female), the basal third of the disc strongly gibbous. Hemelytra rather broad, the costal margins slightly ampilate, then weakly sinuate near their bases; the embolium nearly as wide as the corium; coria only slightly longer than the scutellum, their free apical margins straight, their external apical angles subobtusely rounded; membranes distinctly exceeding the abdomen, the veins rameose. Connexivum narrowly exposed, the apical angles of the segments distinctly produced, obtusely rounded, producing an incised or crenated abdominal margin.

Bucculae well developed, feebly increasing in height posteriorly and ending abruptly near the base of the head; buccular canal deep and moderately wide. Rostrum arising from a point in line with the eyes and reaching the second visible abdominal sternite, segment I attaining the procoxae, segment II barely reaching the mesocoxae, segment IV distinctly shorter than segment III. Mesosternum feebly tumid bilaterally, hardly sulcate medially, vaguely carinate on the xyphus. Metasternum almost equilaterally hexagonal, provided with a low, median carina. Mesocoxae and metacoxae mutually equidistant. Median abdominal furrow very well developed, broad, reaching the sixth sternite.

Basal plates of the female genital valves, when taken together, forming a transverse ellipse, their combined apical margins producing a mildly arcuate line across the body, their ental margins contiguous for their entire distance.

Type species *Parantiteuchus hemitholus*, new genus, new species.

Closely allied to *Antiteuchus* Dallas but differs from that genus by having a somewhat longer head, sinuate pronotal margins, gibbous base to the scutellum, produced segmental angles of the connexivum, rameose veins in the hemelytral membranes, more prominent bucculae, and differently shaped genital plates.

***Parantiteuchus hemitholus*, new species**

A robust, large, glossy, strongly convex, and broadly oval species, distinguished by a large hump on the base of the scutellum and the crenated abdominal margin. Bright ochraceous with coarse fuscous and piceous punctures and pits very irregularly distributed and tending to congregate in clusters on the scutellum and hemelytra; abdominal venter castaneous to fuscous, each segment provided with an ental subquadrangular, and a larger ectal suboval ochraceous spot on each side near the lateral margin.

Head about two-thirds the median length of the pronotum and distinctly longer than wide between the eyes; the margins vaguely reflexed, surface flat, the punctures ferruginous for the most part, more regularly distributed than elsewhere, those on the tylus and a cluster between each eye and the

vertex, piceous. Basal two antennal segments fulvous, segments III and IV fuscous, segment V missing; the joints, a central narrow annulus on segment III and the base of segment IV sordid ivory; segmental ratios: 25/25/79/80/—, i.e., segment II subequal to segment I, a little less than one third the length of segment III, and partially connate with it.

Pronotum not quite two and one-half times as wide as long, the surface before the transhumeral diameter declivous, very rough, densely pitted with deep, very coarse, fuscous to piceous punctures arranged in irregular rows and clusters between which are elevated, very glossy, calloused ochraceous areas, the most conspicuous of which is a median, inverted Y-shaped one just behind the center of the anterior margin; anterior margin wider than the head through the eyes, mildly excavated centrally, the anterior apical angles produced into prominent laterally directed ochraceous conical tubercles; anterolateral margins narrowly carinate, weakly reflexed, and angularly sinuate at their middles; the cicatrices moderately tumid, the humeri more strongly so, the latter fuscous on the anterior face, flavescent on the posterior face; the carina of each anterolateral margin ending abruptly just before the humerus, leaving a minute, obscure emargination there; humeral angles rounded, subrectilinear. Scutellum about one-third longer than wide at the base; the basal area elevated into a half-dome shaped transversely oval hump (hence the specific name *hemitholus*), the crest of which is distinctly higher than the surface of the pronotum, the anterior face of which is subvertical, and the posterior face of which is strongly declivous, sloping toward the middle of the shield (Fig. 2); the crest provided with four, transversely placed, partially pitted, prominent, fuscous patches, the declivous posterior face bright ochraceous and very glossy with three or four scattered large fuscous punctures and a pair of irregular, densely punctured fuscous bands on its slope near the midline; dense clusters of fuscous punctures in the vicinity of the area where the frena end, the anteapical discal portion provided with widely spaced fuscous punctures; the middle area of the disc, just behind the basal hump broadly and obtusely keeled; the apex semicircularly rounded. Hemelytra barely longer than the scutellum, glossy pale flavescent with irregular, densely punctured, fuscous areas, the basal portion of the embolium deeply pitted; membranes distinctly exceeding the abdomen, pale, clear yellowish, darkening slightly toward the base, the veins raised, contrastingly darker brown and forming a dendritic design. Connexivum narrowly exposed, coarsely and sparingly punctured, the basal half of each segment fuscous, the apical half ochraceous, the apical angles of the segments obtusely rounded and distinctly produced.

Thoracic pleura and acetabula glossy, ochraceous with coarse, deep fuscous punctures; evaporatorium contrastingly matte, fuscous. Mesosternum fulvous, metasternum piceous, the median carina moderately developed. Legs flavescent, glossy, the femora provided with a broad, apical castaneous annulus and one or two similarly colored spots on the shaft, tibiae with proximal, central and distal castaneous narrow annuli, the proximal and distal segments of the tarsi fuscous, the middle one flavescent. Abdomen as described above; the surface essentially impunctate, glabrous, but coarsely

alutaceous; the pseudosuture behind each spiracle elevated, so as to give the appearance of being carinate.

Basal plates of the female genital valves subtriangularly oval, a little broader than long, and when taken together forming a transverse elliptical figure, with the combined apical margins weakly arcuate to form a curved line.

Described from one specimen.

HOLOTYPE Female. 15.5 mm. long; 9.5 mm. wide across the humeri; 10.5 mm. wide across the greatest abdominal diameter. French Guiana. No date. Deposited in the American Museum of Natural History.

As a new species in a new genus, there is at present no close affiliate. In superficial appearance, size, and color pattern it somewhat resembles *Antiteuchus variolosus* (Westwood); but the prominent elevation on the scutellum and the distinctly produced angles of the abdominal segments immediately differentiate it.

AN ANNOTATED LIST OF THE LYCAENIDAE (LEPIDOPTERA: RHOPALOCERA) OF THE WESTERN HEMISPHERE

BY WILLIAM PHILLIPS COMSTOCK AND EDGAR IRVING HUNTINGTON

[Continued]

pacis Draudt, Max, *Itylos*

Type Locality: Cuzeo, Peru.

Location of Type:

Original Description: 1921 (January), *The Macrolepidoptera of the World*, vol. 5, p. 821, pl. 144-1, m. (Stuttgart).

pactya Hewitson, W. C., *Thecla*

Type Locality: Ecuador and Bogotá.

Location of Type: British Museum (Natural History).

Original Description: 1874 (December), *Illus. of Diurnal Lepidoptera*, vol. 1, p. 167, vol. 2, pl. 66, figs. 446, 467 ♂ (London).

paetus Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Chiriquí, Panamá.

Location of Type: British Museum (Natural History).

Original Description: 1887 (September), *Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera*, vol. 2, p. 87, vol. 3, pl. 58, figs. 1, 2 ♂ (London).

palegon Cramer, Pierre, *Papilio*

Type Locality: "Sierra Leona, sur la cote d'or de l'Afrique."

Location of Type:

Original Description: 1780, *Papillons exotiques des trois parties du monde*, vol. 3, p. 159, pl. 282, figs. C, D (Amsterdam).

Additional Reference: Godman, F. D. and O. Salvin, 1887 (May), *Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera*, vol. 2, p. 37 (London). (Give the extensive Central American and South American range of this species.)

Synonyms: *juicha* Reakirt, *juica* (Zool. Record), *myrtillus* Cramer, *mytillus* Godman and Salvin, syn.

pallescens Tilden, J. W. and J. C. Downey, *Philotes*

Type Locality: Little Granite Mountain, Dugway Proving Grounds, Tooele County, Utah, August 20, 1953.

Location of Type: California Academy of Sciences, San Francisco, California.

Original Description: 1955 (May), *Bull. Southern California Acad. Sci.*, vol. 54, pt. 1, p. 25, pl. 11, figs. 1 and 3, pl. 12, figs. 4-6 (Los Angeles, Calif.).

pallida Gunder, J. D., *Plebeius monticola* ab. ♀

Type Locality: Cajon Pass, San Bernardino Mountains, San Bernardino County, California, May 12, 1922.

Location of Type: American Museum of Natural History.

Original Description: 1925 (January), Ent. News, vol. 36, p. 3, pl. I, fig. N (Philadelphia, Pa.).

pallida Lathy, Percy I., *Thecla dolylas*

Type Locality: ?

Location of Type: Fournier Collection, Paris.

Original Description: 1930 (June), Trans. Ent. Soc. London, p. 135, (London).

pallida Dufrane, Abel, *Thecla davara joannisi* ab.

Type Locality: Trujillo, Peru.

Location of Type:

Original Description: 1939 (August), Bull. Ann. Soc. Ent. Belgique, vol. 79, p. 291 (Bruxelles).

Note: Invalid name and homonym of *pallida* Lathy.

palumbes Druce, Hamilton H., *Thecla*

Type Locality: Cayenne, French Guiana.

Location of Type: Godman Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 617 (London).

Additional Reference: Draudt, Max, 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 800 (Stuttgart). (Places *palumbes* as a subspecies of *cerata* Hewitson).

pan Drury, Dru, *Papilio*

Type Locality: Jamaica, B. W. I.

Location of Type:

Original Description: 1773, Illus. Nat. Hist., vol. 2, p. 40, pl. 23, figs. 3, 4 (London).

Additional Reference: Comstock, W. P. and E. I. Huntington, 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 71 (New York).

Synonyms: *tirrhaea* Möschler, *pau* (Zool. Record).

pan, Harris, Thaddeus William, *Thecla* (not Drury)

Type Locality: Massachusetts.

Location of Type:

Original Description: 1833, in Hitchcock's Report Geol. and Min. Massachusetts, 1st edition, p. 590 (Boston, Mass.).

Additional Reference: Seudder, Samuel H., 1876 (May), Bull. Buffalo Soc. Nat. Sci., vol. 3, p. 107 (Buffalo, N. Y.). (Places *pan* Harris as a synonym of *melinus* Hübner.)

panamensis Draudt, Max, *Thecla*

Type Locality: Panamá.

Location of Type:

Original Description: 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 801, pl. 158-i (Stuttgart).

panchaea Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1869 (April), Illus. of Diurnal Lepidoptera, vol. 1, p. 126, vol. 2, pl. 51, figs. 274, 275 ♀ (London).

Synonyms: *scoteia* Hewitson.

pantoni Comstock, W. P. and E. I. Huntington, *Thecla angelia*

Type Locality: Baron Hill, Trelawny, Jamaica, B. W. I. March.

Location of Type: American Museum of Natural History.

Original Description: 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 69 (New York).

paphia Felder, Cajetan and Rudolf Felder, *Pseudolycaena*

Type Locality: New Granada, Bogotá.

Location of Type:

Original Description: 1864–1867, Reise den Österreichischen Fregatte "Novara" um die Erde, vol. 2, p. 243, pl. 28, figs. 12, 13 (Wien).

Additional Reference: Draudt, Max, 1919 (November), The Macrolepidoptera of the World, vol. 5, p. 746 (Stuttgart). (Places *paphia* as a form of *cypria* "Hübner.")

paphlagon Felder, Cajetan and Rudolf Felder, *Pseudolycaena*

Type Locality: New Granada, Bogotá.

Location of Type:

Original Description: 1864–1867, Reise der Österreichischen Fregatte "Novara" um die Erde, vol. 2, p. 249, pl. 31, figs. 10, 11 (Wien).

Additional References: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 594 (London). (Describes male); 1909 (September), Trans. Ent. Soc. London, p. 434, pl. 11, fig. 1 ♂ (London).

paradoxa Chermock, F. H., *Plebeius melissa*

Type Locality: Tehachapi Mountains, California, June 7–10, 1927.

Location of Type: Author's Collection.

Original Description: 1944 (November), Can. Ent., vol. 76, p. 214 (Guelph, Ont.).

paraguayensis Lathy, Percy I., *Thecla linus*

Type Locality: Patino, Paraguay.

Location of Type: Fournier Collection, Paris.

Original Description: 1926, Ann. Mag. Nat. Hist., Series 9, vol. 17, p. 42 (London).

paralus Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Deuñas, Guatemala.

Location of Type: British Museum (Natural History).

Original Description: 1887 (September), *Biologia Centrali-Americana*, *Insecta, Lepidoptera-Rhopalocera*, vol. 2, p. 69, vol. 3, pl. 56, figs. 18, 18 (London).

parasia Hewitson, W. C., *Thecla*

Type Locality: Chontales, Nicaragua.

Location of Type: British Museum (Natural History).

Original Description: 1874 (December), *Illus. of Diurnal Lepidoptera*, vol. 1, p. 170, vol. 2, pl. 67, figs. 480, 481 ♂ (London).

Additional Reference: Godman, F. D. and O. Salvin, 1887 (August), *Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera*, vol. 2, p. 50 (London). (Make *parasia* a synonym of *keila* Hewitson).

pardalis Behr, Hermann, *Lycaena*

Type Locality: Contra Costa Range, vicinity of San Antonio, California, May-June.

Location of Type:

Original Description: 1867 (January), *Proc. Calif. Acad. Nat. Sci.*, vol. 3, p. 279 (San Francisco, Calif.).

Synonyms: *erymus* Boisduval, *windi* Gunder.

Subspecies: *fenderi* Macy.

paron Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Purula, Guatemala.

Location of Type: British Museum (Natural History).

Original Description: 1887 (September), *Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera*, vol. 2, p. 70, vol. 3, pl. 56, figs. 24, 25 ♂. (London).

parrhasioides Wallengrén, H. D. J., *Lycaena*

Type Locality: Galápagos Islands, May.

Location of Type: Stockholm Museum.

Original Description: 1860, *Wiener Ent. Monat.*, vol. 4, p. 37, no. 15 (Wien).

parthenia Hewitson, W. C., *Thecla*

Type Locality: Nicaragua (Chontales).

Location of Type: British Museum (Natural History).

Original Description: 1874 (December), *Illus. of Diurnal Lepidoptera*, vol. 1, p. 174, vol. 2, pl. 68, figs. 502, 503 ♂ (London).

partunda Hewitson, W. C., *Thecla*

Type Locality: Bolivia and the Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1877 (January), *Illus. of Diurnal Lepidoptera*, vol. 1, p. 206, vol. 2, pl. 82, figs. 685, 686 ♂ (London).

Synonyms: *origo* Godman and Salvin. (March 29, 1941, Comstock and Huntington recognize *origo* as species.)

parvinotus Kaye, William J., *Siderus*

Type Locality: Botanical Gardens, Port of Spain, Trinidad, B. W. I., May, 1898.

Location of Type: Kaye Collection

Original Description: 1904, Trans. Ent. Soc. London, p. 195 (London).

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 591 (London). (Makes *parvinotus* a synonym of *leucophaeus* Hübner.)

parvipuncta Lathy, Percy I., *Thecla phoster*

Type Locality: Rio Tono, Peru, 1200 ft. (1 ♂, 1 ♀).

Location of Type: Fournier Collection, Paris.

Original Description: 1926, Ann. Mag. Nat. Hist., Series 9, vol. 17, p. 44 (London).

paseo Lucas, P. H., *Thecla*

Type Locality: Havana, Cuba.

Location of Type:

Original Description: 1857, in Sagra, *Histoire physique, politique et naturelle de l'ile de Cuba*, vol. 7, p. 609 (Paris).

Additional Reference: Comstock, W. P. and E. I. Huntington, 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 56 (New York). (Did not recognize the species.)

pastor Butler, A. G. and Herbert Druce, *Strymon*

Type Locality: Cartago, Costa Rica.

Location of Type: British Museum (Natural History).

Original Description: 1872 (July), Cistula Entomologica, vol. 1, p. 105 (London).

Additional References: Butler, A. G., 1873 (October), Lepid. Exot., p. 157, pl. 57, fig. 5 ♀ (London). Godman, F. D. and O. Salvin, 1887 (May), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 34, vol. 3, pl. 52, figs. 8, 9 ♂, 10 ♀ (London). (These figures represent *longula* Hewitson.) Clench, H. K., 1944 (July), Bull. Mus. Comp. Zool., vol. 94, p. 239 (Cambridge, Mass.). (Places *pastor* as a synonym of *longula* Hewitson in error.)

patago Mabille, Paul, *Lycaena*

Type Locality: Punta Arenas, Patagonia.

Location of Type: Paris Museum.

Original Description: 1889, Nouvelles Archives du Museum d'Histoire Naturelle (3), vol. 1, p. 143, pl. 10, figs. 1, 2 (Paris).

patersonia Brehme, H. H., *Thecla damon* var.

Type Locality: Garret Rock, Paterson, New Jersey, July 25 (♀).

Location of Type: Brehme Collection.

Original Description: 1907 (March), Ent. News, vol. 18, p. 82 (Philadelphia, Pa.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 25 (Los Angeles, Calif.). (Makes *patersonia* a synonym of *smilacis* Boisduval and LeConte.)

pau, *Thecla* Misspelling of *pan* Drury

Type Locality:

Location of Type:

Original Description: 1870, Zool. Record., vol. 6, p. 371, (London).

paulina Draudt, Max, *Thecla* (Staudinger in lit.)

Type Locality:

Location of Type:

Original Description: 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 781 (Stuttgart). (Places *paulina* in synonymy of *acameda* Hewitson.)

paupera Felder, Cajetan and Rudolf Felder, *Pseudolycaena*

Type Locality: New Granada, Bogotá.

Location of Type:

Original Description: 1864–1867, Riese der Österreichischen Fregatte, "Novara" um die Erde, vol. 2, p. 246, pl. 31, fig. 15 (Wien).

Subspecies: *harrietta* Weeks.

peculiaris Lathy, Percy I., *Thecla*

Type Locality: Petropolis, Brazil, October 11, 1875 (1 ♂).

Location of Type: Fournier Collection, Paris.

Original Description: 1930 (June), Trans. Ent. Soc. London, p. 136, pl. 9, fig. 14 ♂ (London).

pedusa Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 87, vol. 2, pl. 34, figs. 60, 61 ♂ (London).

pelion Cramer, Pierre, *Papilio*

Type Locality: "Borbice."

Location of Type:

Original Description: 1775, Papillons exotiques des trois parties du monde, vol. 1, p. 10, pl. 6, figs. E, F (Amsterdam).

Synonyms: *aeolus* Fabricius, *simplex* Walch, *thallus* Cramer.

pelops Cramer, Pierre, *Papilio*

Type Locality: Surinam.

Location of Type:

Original Description: 1781, Papillons exotiques des trois parties du monde, vol. 4, p. 98, pl. 341, fig. A (Amsterdam).

Additional References: Kirby, W. F., 1871, A Synonymic Catalogue of

Diurnal Lepidoptera, p. 386 (London). (Makes *pelops* a synonym of *caranus* Cramer.) Goodson, F. W., 1945 (December), Entomologist, vol. 78, p. 186 (London). (Makes *pelops* a synonym of *getus* Fabricius which he considers a distinct species from *caranus* Cramer.)

Note: *Papilio pelops* Cramer, vol. 4 (1781) (Lycaenidae) is a homonym of *Papilio pelops* Cramer, vol. 2 (1777) (Riodinidae).

pelorias Weymer, Gustav, *Lycaena*

Type Locality: Sajama, Bolivia, 3600–4600 m.

Location of Type:

Original Description: 1890, in Reiss and Stübel, Reisen in Sud-Amerika, p. 121, pl. 4, fig. 2 (Berlin).

pembina Edwards, William H., *Lycaena*

Type Locality: Lake Winnipeg, Manitoba, Canada.

Location of Type:

Original Description: 1862 (April), Proc. Acad. Nat. Sci., Phila., p. 224 (Philadelphia, Pa.).

Additional Reference: McDonough, J. H., 1938, Check list, pt. 1, p. 27, no. 455 (Los Angeles, Calif.). (Places *pembina* as a subspecies of *icarioides* Boisduval.)

pennatus Druce, Hamilton H., *Thecla*

Type Locality: Tapajos, Ega and Pará, Amazonas, Brazil.

Location of Type: Godman Collection (British Museum).

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 617 (London).

penroseae Field, William D., *Lycaena mariposa*

Type Locality: Lake Eleanor, Yellowstone National Park, elevation 8500 ft., July 21, 1936.

Location of Type: F. M. Brown Collection, Colorado Springs, Colorado.

Original Description: 1938 (July), Pan-Pacific Entomologist, vol. 14, no. 3, p. 142 (San Francisco, Calif.).

peona Hewitson, W. C., *Thecla*

Type Locality: None.

Location of Type: British Museum (Natural History).

Original Description: 1874 (December), Illus. of Diurnal Lepidoptera, vol. 1, p. 169, vol. 2, pl. 66, figs. 477 ♂, 478, 479 ♀ (London).

peonida Draudt, Max, *Thecla*

Type Locality: Río Aguaca Valley, Colombia.

Location of Type: Fassl Collection, (now in Naturhistorisches Museum, Basle).

Original Description: 1919 (December), The Macrolepidoptera of the World, vol. 5, p. 754, pl. 159-a (Stuttgart).

peralta Möschler, H. B., *Thecla*

Type Locality: Paramaribo, Surinam (1 ♀).

Location of Type:

Original Description: 1883, Verh. Zool.-bot. Ges., vol. 32, p. 308, pl. 17, fig. 1 (Wien).

Additional Reference: Draudt, Max, 1920 (January), The Macrolepidoptera of the World, vol. 5, p. 769 (Stuttgart). (Places *peralta* as a synonym of *comana* Hewitson.)

perdistincta Kaye, William James, *Tmolus*

Type Locality: ? Tabaquite ?, Trinidad, May, 1898.

Location of Type: Kaye Collection.

Original Description: 1904 (June), Trans. Ent. Soc. London, p. 194, pl. 18, fig. 8 (♀ ?) London.

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 607 (London). (Makes *perdistincta* (♀) a synonym of *hesperitis* Butler and Druce.)

pereza Butler, A. G., *Tmolus*

Type Locality: Prainha, December 8, 1873; Pupunha, Río Juruá, November 5, 1974, Brazil.

Location of Type: British Museum (Natural History).

Original Description: 1877 (June), Trans. Ent. Soc. London, p. 140 (London).

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 619 (London). (Makes *pereza* a synonym of *celmus* Cramer.)

perisus Druce, William H., *Thecla*

Type Locality: Venezuela (Kaden Collection).

Location of Type: Godman Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 610 (London).

Additional Reference: Draudt, Max, 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 797, pl. 158-c (Stuttgart).

perkinsae Kaye, William J., *Leptotes*

Type Locality: Baron Hill, Jamaica, B. W. I.

Location of Type:

Original Description: 1931, Trans. Ent. Soc. London, vol. 79, p. 534, pl. 39, figs. 2, 5 (London).

perola Hewitson, W. C., *Thecla*

Type Locality: Amazon (St. Paulo).

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 112, vol. 2, pl. 40, figs. 137, 138 ♀, pl. 46, figs. 211, 212 ♂ (London).

Note: The two sets of figures look like two different species.

perpenna Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Chiriquí, Panamá.

Location of Type: British Museum (Natural History).

Original Description: 1887 (May), *Biologia Centrali-Americana Insecta, Lepidoptera-Rhopalocera*, vol. 2, p. 27, vol. 3, pl. 51, figs. 3, 4 ♂ (London).

perplexa Barnes, William and F. H. Benjamin, *Callophrys dumetorum* race

Type Locality: San Diego, California.

Location of Type: Barnes Collection, United States National Museum.

Original Description: 1923, *Contributions to the natural history of the Lepidoptera of North America*, vol. 5, p. 65 (Decatur, Illinois).

persensis Dufrane, Abel, *Thecla cestri*

Type Locality: Trujillo, Peru.

Location of Type:

Original Description: 1939 (August), *Bull. Ann. Soc. Ent. Belgique*, vol. 79, p. 290 (Bruxelles).

peruviana Erschoff, N., *Thecla*

Type Locality: Peru.

Location of Type:

Original Description: 1876, *Trudy Russkago Ent. Obochestva*, vol. 10, p. 57, pl. 1, fig. 4 ♂ (St. Petersburg).

Additional Reference: Druce, H. H., 1907 (June), *Proc. Zool. Soc. London*, p. 587 (London). (Makes *peruviana* a synonym of *ocrisia* Hewitson.)

peruviana Lathy, Percy I., *Eumaeus minyas*

Type Locality: Chanchamayo, Peru.

Location of Type: Fourniner Collection, Paris.

Original Description: 1926, *Ann. Mag. Nat. Hist.*, Series 9, vol. 17, p. 39 (London).

peruviana Lathy, Percy I., *Thecla*

Type Locality: Chanchamaya, Peru (1 ♀).

Location of Type: Fournier Collection, Paris.

Original Description: 1936, *Livre jubilaire de M. Eugene-Louis Bouvier*, p. 29, pl. 8, fig. 2 (♀) (Paris).

Note: A homonym of *Thecla peurviana* Erschoff (1876).

petaurister Druce, Hamilton H., *Thecla*

Type Locality: Quonga, British Guiana.

Location of Type: Godman Collection.

Original Description: 1907 (June), *Proc. Zool. Soc. London*, p. 613 (London).

petelina Hewitson, W. C., *Thecla*

Type Locality: Chiriquí.

Location of Type: British Museum (Natural History). (Godman and

Salvin (1887) state that type was in Staudinger Collection.)

Original Description: 1877 (January), Illus. of Diurnal Lepidoptera, vol. 1, p. 199, vol. 2, pl. 79, figs. 643, 644 ♀ (London).

petilla Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 20 (London).

Additional Reference: Hewitson, W. C., 1873 (February), Illus. of Diurnal Lepidoptera, vol. 1, p. 139, vol. 2, pl. 55, figs. 332, 333 ♂ (London).

petitioni Comstock, W. P. and E. I. Huntington, *Thecla acis*

Type Locality: Port-au-Prince, Haiti.

Location of Type: American Museum of Natural History.

Original Description: 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 64, pl. 1, fig. 4 ♀ (New York).

petus Fabricius, Johann Christian, *Rurales*

Type Locality: Surinam.

Location of Type:

Original Description: 1793, Entomologica Systematica, vol. 3, p. 264 (Hafniae).

Additional Reference: Goodson, F. W., 1945 (December), Entomologist, vol. 78, p. 186 (London). (Considers *petus* to be a misspelling of *getus* Fabricius.)

phacana Draudt, Max, *Thecla*

Type Locality: Río Negro and Aguaca Valley, Colombia (2 ♀).

Location of Type:

Original Description: 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 790, pl. 157-d (Stuttgart).

phaea Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Volcán de Chiriquí, Panamá.

Location of Type: British Museum (Natural History).

Original Description: 1887 (May), Biologia Centrali-Americanana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 32, vol. 3, pl. 51, figs. 27, 28 ♂, 29 ♀ (London).

phaedrus Hall, Gaylord C., *Heodes epixanthe* subsp.

Type Locality: Dublin Shore, Lunenburg County, Nova Scotia.

Location of Type: American Museum of Natural History.

Original Description: 1924 (June), Jour. New York Ent. Soc., vol. 32, p. 111 (Lancaster, Pa.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 26, no. 434 (Los Angeles, Calif.). (Places *phaedrus* as a synonym of *amicetus* "Scudder.")

Synonyms: *amicetus* Doubleday (nomen nudum).

phaenna Godman, F. D. and O. Salvin, *Thecla*

Type Locality: San Pedro, Honduras and Chontales, Nicaragua.

Location of Type: British Museum (Natural History).

Original Description: 1887 (May), *Biologia Centrali-Americana Insecta, Lepidoptera-Rhopalocera*, vol. 2, p. 31 (London).

Additional References: Godman, F. D. and O. Salvin, 1901 (October), *Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera*, vol. 2, p. 715 (London). (Makes *phaenna* a synonym of *sito* Boisduval.) Hoffman, Carlos C., 1940, *Cat. Syst. Zool. Lep. Mexico*, pt. 1, *Ann. Inst. Biol. Mexico*, vol. 11, no. 2. p. 706 (Mexico City, Mexico). (Places *phaenna* as synonym of *sito* Boisduval.)

phaeomallus Hübner, Jacob *Zesius*

Type Locality: Surinam.

Location of Types:

Original Description: 1823, *Zuträge zur Sammlung exotischer Schmettlinge*, vol. 2, p. 15, pl. (46), figs. 261, 262 (Augsburg).

Note: There seems to be no doubt that this is an East Indian species.

phalanthus Cramer, Pierre, *Papilio*

Type Locality: Surinam.

Location of Type:

Original Description: 1780, *Papillons exotiques des trois parties du monde*, vol. 4, p. 85, pl. 333, figs. C, D (Amsterdam).

Additional Reference: Druce, H. H., 1907 (June), *Proc. Zool. Soc. London*, p. 568 (London). (Did not recognize the species.)

Synonyms: *phalantus* Hübner, *philanthus* Scudder.

phalantus Hübner, Jacob, *Molus* (not Cramer) Misspelling of *phalanthus*

Type Locality:

Location of Type:

Original Description: 1819, *Verzeichniss bekannter Schmettlinge*, p. 78, no. 791 (Augsburg).

phaleros Linnaeus, Carolus, *Papilio*

Type Locality: "In India."

Location of Type:

Original Description: 1767, *Systema Naturae*, vol. 1, pt. 2, 12th Edition, p. 796 (Holmiae).

Additional Reference: Godman, F. D. and O. Salvin, 1887 (May), *Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera*, vol. 2, p. 22, vol. 3, pl. 50, figs. 4, 5, ♂, 6 ♀ (London).

Synonyms: *silenissa* Herbst, *agis* Drury, *chiton* Fabricius, *silenus* Cramer.

phallica Hewitson, W. C., *Thecla olbia* var.

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 97, vol. 2, pl. 40, fig. 136 ♀ (London).

pharus Druce, Hamilton H., *Thecla*

Type Locality: Pará, Brazil.

Location of Type: Godman Collection (British Museum).

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 586, pl. 34, fig. 7 ♂ (London).

phegeus Hewitson, W. C., *Thecla*

Type Locality: Bahia and Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1865, Illus. of Diurnal Lepidoptera, vol. 1, p. 75, vol. 2, pl. 30, figs. 26, 27 ♂ (London).

pheres Boisduval, Jean A., *Lycaena*

Type Locality: San Francisco, California.

Location of Type: United States National Museum?

Original Description: 1852, Ann. Soc. Ent. France, Series 2, vol. 10, p. 297 (Paris).

Additional Reference: Oberthür, Charles, 1913 (October), Etudes de Lépidoptérologie Comparee, fasc. 9, pt. 1, p. 41, pl. 237 figs. 1944 ♂, 1945 ♀ (Rennes).

Synonym: *orcus* Edwards.

philanthus Stoll, Caspar, *Papilio*

Type Locality:

Location of Type:

Original Description: 1787, Papillons exotiques des trois parties du monde, Supplement, p. 23, pl. 5, figs. 3, 3 C (Amsterdam).

Additional Reference: Kirby, W. F., 1871, A Synonymic Catalogue of Diurnal Lepidoptera, p. 380 (London). (Makes *philanthus* female a synonym of *pholeus* Cramer.)

philanthus Scudder, Samuel H., *Molus* (not Cramer) Misspelling of *philanthus* Cramer

Type Locality:

Location of Type:

Original Description: 1875, Proc. Amer. Acad. Arts. Sci. Boston, vol. 10, p. 220, no. 708 (Boston, Mass.).

philemon Boisduval, Jean A., *Lycaena*

Type Locality: Central California.

Location of Type: United States National Museum?

Original Description: 1869, Ann. Soc. Ent. Belgique, vol. 12, p. 47 (Bruxelles).

Additional References: Oberthür, Charles, 1913 (October), Etudes de

Lepidopterologie Comparee, fasc. 9, pt. 1, p. 42, pl. 238, fig. 1965 ♂, pl. 239, fig. 2066 ♀ (Rennes). Strecker, Herman, 1878, Butterflies and Moths of North America. A Complete Synonymical Catalogue, p. 94 (Reading, Pa.). (Makes *philemon* a synonym of *anna* Edwards.)

philenus Poey, Felipe, *Polyommatus*

Type Locality: Cuba.

Location of Type:

Original Description: 1851 (1852), Memorias sobre la historia natural de la isla de Cuba, p. 197 (Habana, Cuba).

Note: Poey changes the spelling of *filenus* (1832); *philenus* is, therefore, synonymous.)

phileros Boisduval, Jean A., *Lycaena*

Type Locality: Mountains of eastern California.

Location of Type: United States National Museum?

Original Description: 1869, Ann. Soc. Ent. Belgique, vol. 12, p. 50 (Bruxelles).

Additional References: Oberthür, Charles, 1913 (October), Etudes de Lepidopterologie Comparee, fasc. 9, ppt., 1, p. 43, pl. 239, figs. 2076 ♂, 2077 ♀ (Rennes). McDunnough, J. H., 1938, Check list, pt. 1, p. 27, no. 455 (Los Angeles, Calif.). (Places *phileros* as a synonym of *icariooides* Boisduval.)

philinna Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 19 (London).

Additional Reference: Hewitson, W. C., 1873 (February), Illus. of Diurnal Lepidoptera, vol. 1, p. 139, vol. 2, pl. 55, figs. 334, 335 ♂ (London). Cayenne.

Synonyms: *unilinea* Kaye.

phlaeas Auctorum, *Lycaena* (not Linnaeus) see *hypophlaeas* Boisduval

Type Locality:

Location of Type:

Original Description:

phleas Morris, John G., *Lycaena*? See *phlaeas* Linnaeus

Type Locality: United States and Africa.

Location of Type:

Original Description: 1860, Catalogue of the Described Lepidoptera of North America, p. 12 (Washington, D. C.).

Note: This is an obvious misspelling of *phlaeas*.

phobe Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Chisoy Valley, Guatemala.

Location of Type: British Museum (Natural History).

Original Description: 1887 (June), *Biologia Centrali-Americanana, Insecta, Lepidoptera-Rhopalocera*, vol. 2, p. 47, vol. 3, pl. 53, figs. 27, 28 ♂, 29 ♀ (London).

phoenissa Hewitson, W. C., *Thecla*

Type Locality: Amazon (Pará).

Location of Type: British Museum (Natural History).

Original Description: 1867, *Illus. of Diurnal Lepidoptera*, vol. 1, p. 100, vol. 2, pl. 40, figs. 139, 140 ♂ (London).

pholeus Cramer, Pierre, *Papilio*

Type Locality: Surinam.

Location of Type:

Original Description: 1777, *Papillons exotiques des trois parties du monde*, vol. 2, p. 104, pl. 163, figs. D, E (Amsterdam).

Additional Reference: Druce, H. H., 1907 (June), *Proc. Zool. Soc. London*, p. 599 (London). (Points out the difference between *pholeus* and *selina* Hewitson.)

Synonyms: *feminalis* Draudt, *philanthus* Stoll.

Subspecies: *meridionalis* Draudt.

phoster, Druce, Hamilton H., *Thecla*

Type Locality: Surinam.

Location of Type: Druce Collection.

Original Description: 1907 (June), *Proc. Zool. Soc. London*, p. 597, pl. 35, fig. 8 ♂ (London).

photineos Druce, Hamilton H., *Thecla*

Type Locality: Quonga, British Giana.

Location of Type: Godman Collection.

Original Description: 1907 (June), *Proc. Zool. Soc. London*, p. 573, pl. 31, fig. 8 ♂ (London).

Additional Reference: Draudt, Max, 1919 (November), *The Macrolepidoptera of the World*, vol. 5, p. 749, pl. 147-f (Stuttgart). (Makes *photineos* a subspecies of *viresco* Druce.)

photismos Druce, Hamilton H., *Thecla*

Type Locality: Sarayacu, Ecuador.

Location of Type: Godman Collection (British Museum).

Original Description: 1907 (June), *Proc. Zool. Soc. London*, p. 615, pl. 36, fig. 15 ♂ (London).

phrosine Druce, Hamilton H., *Thecla*

Type Locality: Chanchamayo, Peru, 2000–7500 ft.

Location of Type: H. J. Adams Collection.

Original Description: 1909 (September), *Trans. Ent. Soc. London*, p. 435, pl. 11, fig. 7 ♀ (London).

phruttus Geyer, Carl, *Bythis*

Type Locality: "Java."

Location of Type:

Original Description: 1832, *Zuträge zur Sammlung exotischer Schmettlinge*, vol. 4, p. 26, figs. 703, 704 ♀ (Augsburg).

Additional References: Hewitson, W. C., 1873 (February), *Illus. of Diurnal Lepidoptera*, vol. 1, p. 141, vol. 2, pl. 56, figs. 342 ♂, 340, 341 ♀ (London). (Gives localities Amazon, Venezuela and Rio de Janeiro). Godman, F. D. and O. Salvin, 1887 (September), *Biologia Centrali-Americanana, Insecta, Lepidoptera-Rhopalocera*, vol. 2, p. 88 (London). (Give Central American localities and say that Hewitson's figs. 340 and 341 may not represent this species.)

Note: Geyer spelled the generic name incorrectly; it should be spelled *Bithys* Hübner.

Synonyms *fidentia* Hewitson.

phrynisca Burnieister, H., *Thecla*

Type Locality: Corrientes Province, Argentina.

Location of Type:

Original Description: 1878, *Dese. Physique Republique Argentine*, vol. 5, *Lepid.*, pt. 1, p. 232, *Atlas*, pl. 8, fig. 11 (Buenos Aires).

phydela Hewitson, W. C., *Thecla*

Type Locality: Rio de Janeiro.

Location of Type: British Museum (Natural History).

Original Description: 1867, *Illus. of Diurnal Lepidoptera*, vol. 1, p. 84, vol. 2, pl. 33, figs. 56 ♂, 54, 55 ♀ (London).

piasus Boisduval, Jean A., *Lycaena*

Type Locality: California, in woods in the spring.

Location of Type: United States National Museum?

Original Description: 1852, *Ann. Soc. Ent. France, Series 2*, vol. 10, p. 299 (Paris).

Additional Reference: Oberthür, Charles, 1913 (October), *Etudes de Lepidopterologie Comparee*, fasc. 9, pt. 1, p. 41, pl. 237, fig. 1950 ♂ (Rennes).

Synonyms: *sagittigera* Felder and Felder, *viaca* Edwards.

Subspecies: *catalina* Retakirt, *rhaea* Boisduval syn., *gorgonioi* Gunder syn., *daunia* Edwards.

piasus Auctorum, *Lycaena* (not Boisduval)

Type Locality:

Location of Type:

Original Description:

Note: Behr, Hermann, 1867 (January), *Proc. Calif. Acad. Nat. Sci.*, vol. 3, p. 280 (San Francisco, Calif.), used the name *piasus* for the California race of *pseudargiolus* Boisduval and LeConte. This error appears extensively in the literature.

picentia Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 23 (London).

Additional Reference: Hewitson, W. C., 1873 (February), Illus. of Diurnal Lepidoptera, vol. 1, p. 138, vol. 2, pl. 55, figs. 328, 329 ♀ (London). Tapajos.

Synonyms: *rubifer* Druce.

picus Druce, Hamilton, H., *Thecla*

Type Locality: Roraima, British Guiana.

Location of Type: Godman Collection (British Museum).

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 606, pl. 36, fig. 9 ♀ (London).

pion Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Polochic Valley, Guatemala.

Location of Type: British Museum (Natural History).

Original Description: 1887 (August), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 56, vol. 3, pl. 54, figs. 28, 28a, 29 ♂, 30 ♀ (London).

Note: *pion* may possibly be the male of *panchaea* Hewitson (1869).

pilea Godman, F. D. and O. Salvin, *Thecla*

Type Locality: St. Vincent, B. W. I.

Location of Type: British Museum (Natural History).

Original Description: 1896, Proc. Zool. Soc. London, p. 516 (London).

Synonyms: *subobscura* Lathy.

pisidula Druce, Hamilton H., *Thecla*

Type Locality: Río Grande, Brazil.

Location of Type: Druce Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 618 (London).

Additional Reference: Draudt, Max, 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 800, pl. 158-h (Stuttgart).

pisis Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Bugaba, Panamá.

Location of Type: British Museum (Natural History).

Original Description: 1887 (September), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 84, vol. 3, pl. 57, figs. 24, 25 ♂ (London).

platyptera Felder, Cajetan and Rudolf Felder, *Pseudolycaena*

Type Locality: Venezuela and New Granada, Bogotá.

Location of Type: Godman Collection (British Museum).

Original Description: 1864-1867, Reise der Österreichischen Fregatte "Novara" um die Erde, vol. 2, p. 246, pl. 28, figs. 6, 7 (Wien).

plautus Scudder, Samuel H., *Incisalia*

Type Locality: North America.

Location of Type:

Original Description: 1876 (April), Bull. Buffalo Soc. Nat. Sci., vol. 3, p. 104 (Buffalo, N. Y.).

Note: Scudder places *plautus* in the synonymy of *niphon* Hübner based on Abbot's unpublished drawing in the British Museum. He credited the name *plautus* to Abbot and not to Fabricius. Fabricius gave a reference to Jones' figure "6. tab. 44. fig. 1." His description reads like *niphon* Hübner. The date of *plautus* is 1793; the date of *niphon* is 1823). This should be investigated for possible synonymy.

plinius Butler, A. G., *Lampides cassius* var. (not Fabricius).

Type Locality: Jamaica, B. W. I.

Location of Type:

Original Description: 1870, Catalogue of Diurnal Lepidoptera. Described by Fabricius in the collection of the British Museum, p. 164 (London).

Note: *Hesperia Rurales plinius* Fabricius is an East Indian species.

plumans Druce, Hamilton H., *Thecla*

Type Locality: Chapada Campo, Brazil, December.

Location of Type: Godman Collection (British Museum).

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 622 (London).

plumbea Butler, A. G., *Scolitantides*

Type Locality: Chile.

Location of Type:

Original Description: 1881 (December), Trans. Ent. Soc. London, p. 486 (London).

plusios Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Mexico, Guatemala and Panamá.

Location of Type: British Museum (Natural History).

Original Description: 1887 (September), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 77 (London). (Say that it is near *denarius* and *sethon* and say that it is, perhaps, a doubtful species.

podarce Felder, Cajetan and Rudolf Felder, *Lycaena*

Type Locality: California.

Location of Type:

Original Description: 1864-1867, Reise der Österreichischen Fregatte "Novara" um die Erde, vol. 2, p. 282, pl. 35, figs. 22, 23 (Wien).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 27, no. 452 (Los Angeles, Calif.). (Places *podarce* as a subspecies of *aquilo* Boisduval.)

Synonyms: *cilla* Behr, *nestos* Boisduval, *tehama* Reakirt.

poeas Hübner, Jacob, *Rusticus armatus*

Type Locality:

Location of Type:

Original Description: 1811, Sammlung exotischer Schmetterlinge, vol. 1, pl. (101) (Augsburg).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 24, no. 365 (Los Angeles, Calif.). (Places *poeas* as a synonym of *cecropis* Fabricius. This should be investigated.)

polama Schaus, William, *Thecla*

Type Locality: Petropolis, Castro, Brazil.

Location of Type: United States National Museum, no. 5943.

Original Description: 1902, Proc. U. S. Natl. Mus., vol. 24, p. 416 (Washington, D. C.).

polibetes Cramer, Pierre, *Papilio*

Type Locality: Surinam.

Location of Type:

Original Description: 1781, Papillons exotiques des trois parties du monde, vol. 4, p. 98, pl. 341, figs. B ,C (Amsterdam).

Additional Reference: Godman, F. D. and O. Salvin, 1887 (June), Biologia Centrali-Americanana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 41, vol. 3, pl. 52, figs. 24, 25 ♂, 26 ♀ (London). (As *orgia* Hewitson).

Synonyms: *zoe* Reakirt.

polingi Barnes, William and F. H. Benjamin, *Strymon*

Type Locality: Sunny Glen Ranch near Alpine, Brewster County, Texas.

Location of Type: Barnes Collection, United States National Museum. (Paratype in the American Museum of Natural History.)

Original Description: 1926 (September-December), Bull. Southern Calif. Acad. Sci., vol. 25, pt. 3, p. 94 (Los Angeles, Calif.).

polios Cook, John H. and Frank E. Watson, *Incisalia*

Type Locality: Lakewood, New Jersey, April 27, 1906.

Location of Type: United States National Museum. (Paratype in the American Museum of Natural History.)

Original Description: 1907 (June), Can. Ent., vol. 39, p. 202 (London, Ont.).

Additional Reference: Cook, John H., 1907 (July), *op. cit.*, vol. 39, p. 235, pl. 5 (London, Ont.).

Synonyms: *davisi* Watson and Comstock.

politus Druce, Hamilton H., *Thecla*

Type Locality: Santarem, Brazil.

Location of Type: Godman Collection (British Museum).

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 625, pl. 36, figs. 22 ♂, 23 ♀ (London).

polybe Johansson, Boas, *Papilio*

Type Locality: No locality mentioned in original description. Hewitson gives Rio de Janeiro.

Location of Type:

Original Description: 1763, Centuria Insectorum. Amoen. Acad, vol. 6, p. 404 (Holmiae).

Additional References: Linnaeus, Carolus, 1767, Systema Naturae, vol. 1, pt. 2, 12th edition, p. 787. (Holmiae). Hewitson, W. C., 1869 (April), Illus. of Diurnal Lepidoptera, vol. 1, p. 78, vol. 2, pl. 31, fig. 38 ♂ (London). Godman, F. D. and O. Salvin, 1887 (May), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 19, vol. 3, pl. 49, figs. 12, 13 ♂ (London).

polybetes Hübner, Jacob, *Parrhasius* (not Cramer) See *polibetes* Cramer

Type Locality:

Location of Type:

Original Description: 1819, Verzeichniss bekannter Schmettlinge, p. 70, no. 799 (Augsburg).

polyphemus Boisduval, Jean A., *Lycanea*

Type Locality: California.

Location of Type: United States National Museum?

Original Description: 1869, Ann. Soc. Ent. Belgique, vol. 12, p. 49 (Bruxelles).

Additional References: Oberthür, Charles, 1913 (October), Etudes de Lépidoptérologie Comparee, fasc. 9, pt. 1, p. 42, pl. 239, fig. 2071 (Rennes). McDunnough, J. H., 1938, Check list, pt. 1, p. 28, no. 474 (Los Angeles, Calif.). (Places *polyphemus* as a form of *xerxes* Boisduval.)

ponce Comstock, W. P. and E. I. Huntington, *Thecla bubastus*

Type Locality: Ponce, Puerto Rico, July 20-22, 1914.

Location of Type: American Museum of Natural History.

Original Description: 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 79 (New York).

Additional Reference: Comstock, W. P., 1944 (October), Scientific Survey of Porto Rico and the Virgin Islands, vol. 12, pt. 4, p. 489, pl. 9, fig. 10 ♂, text fig. 14 (New York).

porphyreticus Druce, Hamilton H., *Thecla*

Type Locality: Río Napo, Peru.

Location of Type: Godman Collection (British Museum).

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 593, pl. 35, fig. 2 ♂ (London).

PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MINUTES OF MARCH 17, 1959

President Shoumatoff called the meeting to order at 8:15 PM in Room 419 of the American Museum of Natural History. There were 15 members and 12 guests present. Dr. A. B. Klots reported that the Botanical Garden is being consulted regarding a field trip to be held there. Mrs. P. Vaurie submitted a membership proposal for Dr. H. Ruckes of Dr. Nicholas Kormilev, 367 Lincoln Place, Brooklyn, New York. Mr. Shoumatoff introduced Mr. Ted Weinreich, President of the Junior Society, who briefly discussed the development of the Junior's program. Mr. Heineman suggested that visitors add their addresses after their names in the attendance book so they can be placed on the mailing list.

Mr. Shoumatoff introduced the speaker of the evening, Mr. Bernard Heineman, who spoke on "Insects of Jamaica." His talk, which dealt with the history and the insects of the island, was illustrated with many beautiful colored slides. (An abstract follows the minutes.)

The meeting was adjourned at 10:00 PM.

PETER DIX, *Secretary, pro tem.*

INSECTS OF JAMAICA

Abstract

This talk is more or less a summary of thirteen visits to the Island of Jamaica which is 1600 air miles from New York City and 5½ hours flying time. Its area is roughly 4200 square miles, about 2½ times the size of Long Island. Many upheavals and disturbances have occurred in its geological history. Unlike Bermuda, Nassau and other islands of low altitude, Jamaica has, in addition to beautiful beaches, rolling savannahs, undulating hills, mountain ranges which rise majestically to heights of 7400 feet. The flora is exquisite. There are no venomous snakes, but ants, sand flies, mosquitoes, chiggers, and ticks abound in some areas—and they all bite. When Columbus discovered Jamaica on May 3rd, 1499, it was occupied by a tribe of peaceful Indians called the Arawaks. Their chief claim to fame is that a modern hotel now has been named for them. The Arawaks called the place Xaymaca—"Island of Springs."

By the early 16th century the Spanish had settled the island. They also settled the Arawaks, enslaving and killing them until only the few who escaped to the mountains survived. Slaves were imported by the Spaniards, and, when in 1655 the British captured the island, they, too, brought in negroes from the African Ashanti tribe. When any of these vassals managed to escape, they retreated to secluded spots in the mountainous interior and comingling with the Indians became a marauding group known as the Maroons. Their raids on the colonists became so great that in 1738 Edward Trelawny, the British Governor, signed a treaty giving them tax-free land in the interior and permitting them to elect their own leader with the rank of Colonel.

The average temperature at sea level is 79 degrees with a variance of 5 degrees between that of summer and winter; hot days and cool nights. When it's 80 degrees in the port of Kingston, the capital, it is about 56 degrees on Blue Mountain Peak. Half of Jamaica is over 1000 ft. above sea level. May-June and September-October are generally the wettest months; February, March, April the driest. Butterflies are seen somewhere every day, but the best collecting months are July, August, and November to April after the heavy rains. The natives call butterflies "bots" (bats). Ordinary bats are called "rot bots" (rat bats). I am known as "the bot mon."

Sir Hans Sloane was the first naturalist to write at length on the flora and fauna of Jamaica. His account of his fifteen months' sojourn in 1687 and 1688 is a classic. Since then there have been many famous collectors in Jamaica; the list includes Cramer, Gosse, Gundlach, Kaye, Lily Perkins, Avinoff and Shoumatoff, Watson and Bell. There are about 130 described species on the Island, and 38 of these are indigenous. There are several sight records. Lily Perkins claims to have seen the orange tip of an *Authoheris* type; Avinoff and Shoumatoff describe a Pierid or Ithomid from Lowe River; C. B. Lewis mentions a new *Papilio* from the Blue Mts.; Avinoff and Shoumatoff missed one that they would have named Arawak; and only recently an English collector claims to have seen a *Morpho* at Port Antonio. There is still romance in Jamaica and new fields to conquer. Further collecting should disclose new species in the unexplored mountain regions and the less frequented parishes.

BERNARD HEINEMAN

MEETING OF APRIL 7, 1959

The President called the meeting to order at 8:10 PM in Room 419 of the American Museum of Natural History; 17 members and 5 guests were present. Mr. Shoumatoff stated that the JOURNAL is progressing well. The volume containing the last two quarters of 1958 has been distributed and material for the 1959 volume is ready for the printer. Dr. Nicholas Kormilev was elected to membership. The Junior Society announced they are going to visit the laboratories at Fordham University under the supervision of Dr. Forbes on April 25th and on May 9th Mr. James Sanford is going to speak to them. Dr. John Schmitt reported on the meeting of the Philadelphia Entomological Society held at the Academy of Natural Sciences on March 25th. He felt that it was a successful meeting. However, one item of concern to entomologists is the problem of attracting young people to entomology. The group was glad to hear about the Junior Society which is sponsored by our senior members. Dr. Schmitt expressed his thanks for being able to represent the New York Society at this meeting.

Several recent articles from popular publications were brought to the attention of the Society: a picture story from last Sunday's NEW YORK TIMES on the 90th birthday of the American Museum of Natural History; a picture story of unusual photographers, including our own Dr. Vishniac in the SATURDAY EVENING POST; and a write-up of Dr. Vishniac in the February, 1959 issue of MODERN PHOTOGRAPHY.

Mr. Shoumatoff then introduced Dr. Lucy Clausen, the speaker of the evening, who spoke on "Medicinals of Insect Origin." She displayed several medicinally important insects and examples of pharmaceutical substances derived from insects. Dr. Clausen answered many questions after her interesting talk. (An abstract follows the minutes.)

The meeting adjourned at 10:00 PM.

PETER DIX, *Secretary, pro tem.*

MEDICINALS OF INSECT ORIGIN

Abstract

When a person talks about insects and their relation to medicine, thoughts of insect-caused epidemics are evoked. Less well-known, however, is the reverse situation wherein insects or their products of metabolism serve to alleviate disease conditions. In the introductory remarks the various areas of study basic to the standard acceptance of medicinals of insect origin were explained. Insect substances that are officially recognized as medicinals were divided into nine categories. Each category was defined, an example cited, a standard method of preparation and assay described and the recommendations for use given.

Among the items discussed were: beeswax as a vehicle for penicillin designed for intramuscular injection; honey as a flavoring agent or as a disguise for the disinfectant incorporated in gargles; cochineal as a coloring agent for pink dental preparations; non-absorbable sutures originating from the silk worm, and lae as a coating for tablets calculated to disintegrate within the body at controlled intervals. Although those products that are officially recognized were emphasized, many remedies still used routinely among various cultural groups were mentioned.

L. W. CLAUSEN

MEETING OF APRIL 21, 1959

The meeting was called to order at 8:05 PM by Vice-president Heineman in Room 419 of the American Museum of Natural History. He welcomed the 14 members and 10 guests who were present. Mr. Shoumatoff, our President, is out of town at this time. The minutes of the March 3rd, March 17th, and April 7th meetings were read and approved. It was announced that Dr. Roman Vishniac won a Grand Prize at the photographic show recently held at the New York Coliseum. Dr. and Mrs. Richard Brickner were introduced.

Mr. Heineman introduced the speaker, Dr. T. C. Schneirla, who spoke on "Problems in the Psychology of Insects and Mammals." His talk was illustrated with slides. A lively discussion period followed.

The meeting adjourned at 10:00 PM.

ROBERT G. BLOCH, *Secretary*

MEETING OF MAY 5, 1959

President Shoumatoff called the meeting to order at 8:10 PM in Room 419 of the American Museum of Natural History. The 20 members and

nine guests present were greeted by the President. Dr. J. Schmitt introduced Miss Jean Adams, Mr. Louis Varvory, Mr. Richard Guest, Dr. Granett, and Dr. N. Lau, his guests, who are students and faculty members of Rutgers University. Mr. Heineman stated that the next meeting would be a member's symposium and asked everyone to participate. He, also, asked for suggestions for the coming year. Mr. Soraci, the Editor, said he had enough manuscript material for the fourth issue of this year and some for 1960. Dr. A. Klots announced a field trip to be held on Sunday, May 31st at the National Audubon Center at Greenwich, Conn. Mr. H. Schwarz proposed Mrs. Elsie B. Klots for membership. The By-laws were suspended and she was elected to membership. Mr. David Lohre was proposed by Mr. J. Huberman. An Executive Committee meeting has been called for Monday, May 25, at 6 PM. It was announced that Mr. James Sanford will speak to the Junior Society on May 9th and Dr. J. Schmitt on May 23rd; the Juniors will join with us on our field trip.

The President introduced Dr. E. S. Hodgson, Assistant Professor of Zoology at Columbia University and former Society Secretary, who spoke on "Hormones and Insect Behavior." Movies and slides were used by the speaker to illustrate his talk. A discussion period followed the talk. (An abstract follows the minutes.)

Meeting adjourned at 9:45 PM.

ROBERT G. BLOCH, *Secretary*

HORMONES AND BEHAVIOR IN INSECTS

Abstract

Insect hormones are known to influence growth and development. Recently it has been shown that hormones produced by the neurons in a part of the brain have an effect upon behavior. In order to analyze the mechanisms of these behavioral effects, the hormones were applied to central nervous systems removed from the body and to whole intact insects.

Corpora cardiaca, glands supplied with hormone from cells in the pars intercerebralis of the roach, contain at least three hormones. One hormone is produced by the glands themselves, the other two are derived entirely from the pars intercerebralis. It is the latter type of hormone, termed a neurosecretory hormone, with which this work is concerned. Exposure of central nerve cords to corpus cardiacum extracts *in vitro* results in a pronounced decrease of the spontaneous nerve activity within the nerve cords. When injected into whole intact roaches (*Periplaneta* or *Blaberus*) the extracts induce a more stereotyped behavior pattern than found in the controls. The hypothesis is advanced that secretions passing from the brain to the corpora cardiaca and thence into the hemolymph play a role in determining the overall level of activity in the central nervous system and in the entire animal.

EDWARD S. HODGSON

MEETING OF MAY 19, 1959

Member's symposium—informal reports by members. Minutes not available for this meeting.

**JOURNAL
of the
NEW YORK ENTOMOLOGICAL SOCIETY**

The JOURNAL of the NEW YORK ENTOMOLOGICAL SOCIETY is devoted to the advancement and dissemination of knowledge pertaining to insects and their related forms.

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The
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SMITHSONIAN INSTITUTION OCT 15 1962

THE BEHAVIOR AND HABITS OF THE
MYRMECOPHILOUS SCARAB CREMASTOCHEILUS
STATHAMAE CAZIER WITH NOTES
ON OTHER SPECIES
(COLEOPTERA: SCARABAECIDAE)

BY MONT A. CAZIER¹ AND MARJORIE STATHAM²

RECEIVED FOR PUBLICATION AUGUST 20, 1961

ABSTRACT

A list of all the known host ants and beetle species (Cremastocheilini) is given along with a detailed description of the behavior and habits of *C. stathamae* with the honey ant *Myrmecocystus mimicus*. Information on the feeding habits and behavior of the ant are included. It is determined that the true relationship between the species of the genus *Cremastocheilus* and their host ant species is not yet known and that these beetles are found associated with at least 11 different genera of ants.

Aside from isolated collecting records and brief observations involving only a few specimens of *Cremastocheilus* little is actually known about the behavior of these myrmecophilous beetles or of the intricacies of their relationship with the associated ant species. Wheeler (1908) summarized most if not all of the information available at that time on their behavior and drew several conclusions that do not appear to be entirely in accord with observations made subsequent to his publication. This is not too surprising as Wheeler had only a limited number of published accounts to draw upon and without exception all of them gave only fragmentary and often questionable information. Wheeler's own experiments are not conclusive primarily because of the difficulty in observing the behavior of the beetle underground or in an artificial ant nest.

Brief observations have been made on the occurrence of these beetles with various species of ants on the surface of the ground

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near to or away from the opening to the nests and in the upper galleries of the nest itself. Wheeler introduced several species of *Cremastocheilus* into artificial nests of several species of ants and obtained some interesting behavior information which in part led him to conclude that "the Cremastochili are not true guests, or symphiles, as Wasmann supposed (1894), but persecuted intruders (Synechthrans) that may eventually become indifferently tolerated guests (synoëketes)." There is still too little information available to either verify or disprove this conclusion. However, the observations made on *Cremastocheilus stathamae* Cazier and its behavior in relation to *Myrmecocystis mimicus* Wheeler outside the nest, indicate that in some activities they could be classified as a synechthrans (unwelcome guests), synoëketes (unnoticed or tolerated guests) or as Symphiles (true guests).

Ayre (1958) observing the behavior between adults of *Cremastocheilus armatus* Walker and *Formica integroides subnitens* Creighton suggests that the beetle is a persecuted synoëkete (synechthran). Howden (in lit.) also working in British Columbia on *Cremastocheilus armatus* Walker but in the nest of *Formica subpolita camponoticeps* Wheeler reports that one of two adults taken from the nest was feeding on an ant larvae. This behavior might indicate either a synechthran or symphile relationship with this species of ant. Limited observations made by Cazier (1961) on the behavior of the adults of *Cremastocheilus mentalis* Cazier and the ants *Dorymyrmex pyramicus* (Roger), *Novomessor albisetosus* (Mayr), *Pogonomyrmex maricopa* Wheeler and *P. barbatus* (F. Smith) would indicate symphile relationships at least in part. *Dorymyrmex pyramicus* (Roger) at a different location apparently has no relationship with *Cremastocheilus stathamae* Cazier although both are abundant in the area.

Field observations made by the authors in several localities indicate the existence of differences in behavior on the part of various species of *Cremastocheilus* and in the species of ants in a single location or between different locations. These differences could easily account for the varied and sometimes apparently contradictory reports that have been published on behavior or relationships. It is also possible, and we think probable, that the species of *Cremastocheilus* are at different evolutionary

levels in their development from being unwelcome guests (*Synechthrans*) to true guests (*Symplices*) and that we may yet discover species that are true symbionts. To date little or nothing has been done to study the relationship between the beetle (adults and immature stages) and the ants inside of the colony proper.

As a result of new information it is apparent that Wheeler's (1908, p. 70) statement is at least partly incorrect, "These records show that in the great majority of cases the hosts of *Cremastocheilus* belong to the genus *Formica*. Although *C. spinifer* has been taken with *Pheidole*, *C. variolosus* with *Aphaenogaster* and *C. squamulosus* with a species of *Camponotus*, it is practically certain that these are accidental or irregular associations." We now know that *Cremastocheilus* species are regularly associated with the following ten genera of ants: *Formica*, *Polyergus*, *Camponotus*, *Aphaenogaster*, *Veromessor*, *Pheidole*, *Myrmecocystis*, *Novomessor*, *Popononyrmex* and *Dorymyrmex*. The closely related Scarab *Genuchinus ineptus* (Horn) has been found with ants belonging to the genera *Formica*, *Liometopum* and *Crematogaster*. That the distribution of *Cremastocheilus* conforms closely with that of *Formica* and that they occur more often with species belonging to that genus seems inevitable. According to Creighton (1950, p. 450) the genus *Formica* is the largest genus in North America and its species constitute approximately one-sixth of our entire ant fauna. It occurs throughout the United States, most of southern Canada, and in sections of Mexico.

Table one is a compilation of the known records. The names of the host ants have been changed in many cases to conform to the nomenclature and status established by Creighton (1950).

The authors wish to express their gratitude to Dr. E. Gorton Linsley for the assistance rendered in this study. It was he who first took notes on the beetles' behavior and realized the potentialities of the find even before the size of the population had been determined. We would also like to thank Dr. and Mrs. Alexander B. Klots for finding and keeping track of several specimens on the first day of study and Dr. Henry Howden who supplied information from his own collecting experiences and from the Canadian National Collection. We wish to express our appreciation to Dr. William S. Creighton who made the determinations on the ant species collected in the study plot and to

Table 1

<i>Cremastocheilus</i> species	Host ant species	Locality	Authority
<i>castanea</i> Koch	<i>Formica fusca</i> Linné	North Carolina	Beutenmuller
	<i>Formica schaufussi</i> Mayr	New York	Wheeler
	<i>Formica exsectoides</i> Forel	New Jersey	Davis & Wheeler
	<i>Polyergus lucidus</i> Mayr	Washington, D. C.	Pergande
	<i>Formica pallidefulva</i> <i>nitidiventris</i> Emery as slaves	New York	Wheeler
	<i>Formica fusca</i> Linné	Colorado	Schmitt
	<i>Formica fusca</i> Linné	Kansas	Howden, in lit.
	<i>Formica schaufussi</i> Mayr	New Jersey	Davis & Wheeler
	<i>Formica rubicunda</i> Emery with <i>F. fusca</i> Linné as slaves	New Jersey	Davis & Wheeler
	<i>Formica exsectoides</i> Forel	New Jersey	Davis
<i>canaliculatus</i> Kirby	<i>Formica fusca</i> Linné	Massachusetts	Morse
	<i>Formica fusca</i> Linné	New Hampshire	Howden, in lit.
	<i>Polyergus rufescens</i> <i>bicolor</i> Wasmann with <i>Formica fusca</i> Linné as slaves	Massachusetts	Howden, in lit.
	<i>Camponotus pennsylvanicus</i> (DeGeer)	Ontario	Howden, in lit.
	<i>Formica rufibarbis</i> gnava	Pennsylvania	Hamilton
	<i>Formica obscuripes</i> Forel	Arizona	Schaeffer
	<i>Veromessor andrei</i> (Mayr)	Arizona	Wenzel
	<i>Aphaenogaster fulva</i>	California	Mann
	Roger		Schwarz
	<i>Camponotus (esuriens)</i> probably <i>C. abdominalis</i>	Georgia	
<i>squamulosus</i> LeConte	<i>Fabricius</i> or <i>C. vicinus</i>	Florida	Schwarz
	<i>Formica rufibarbis</i> gnava	Texas	Wheeler
	Buckley		
	<i>Formica rufibarbis</i> gnava	Texas	Wheeler
<i>retractus</i> LeConte	Buckley		
	<i>Formica ciliata</i> Mayr	Colorado	Wheeler
	<i>Formica schaufussi</i> Mayr	North Carolina	Wheeler
	<i>Formica subintegra</i> Emery with <i>F. schaufussi</i> Mayr slaves	New Jersey	Wheeler
<i>harrisi</i> Kirby	<i>Formica subpolita</i>	British Columbia	Howden, in lit.
	<i>camponoticeps</i> Wheeler		
	<i>Formica integroides</i>	British Columbia	Ayre
	<i>subnitens</i> Creighton		
	<i>Veromessor andrei</i> (Mayr)		Essig
<i>armatus</i> Walker			

Table 1—(Continued)

<i>Cremastochelus</i> species	Host ant species	Locality	Authority
<i>pilisicollis</i> Horn	<i>Veromessor andrei</i> (Mayr)	California	Mann
<i>spinifer</i> (Horn)	<i>Formica obscuripes</i> Forel <i>Pheidole desertorum</i> Wheeler	California Texas	Mann Wheeler
<i>wheeleri</i> LeConte	<i>Formica oreas</i> Wheeler <i>Formica criniventris</i> Wheeler <i>Formica microgyna</i> Wheeler <i>Formica rasilis</i> Wheeler <i>Formica ciliata</i> Mayr <i>Formica exsectoides</i> Forel <i>Formica obscuripes</i> Forel	Colorado Colorado Colorado Colorado Colorado Colorado Colorado Manitoba	Wheeler Wheeler Howden, in lit. Wheeler
<i>planatus</i> LeConte	<i>Formica obscuripes</i> Forel <i>Camponotus maccooki</i> Forel <i>Formica rufibarbis</i> <i>occidua</i> Wheeler	Arizona California California	Wheeler Mann Mann
<i>planipes</i> (Horn)	<i>Formica obscuripes</i> Forel	Arizona	Wheeler
<i>opaculus</i> (Horn)	<i>Formica obscuripes</i> Forel	Arizona	Wheeler
<i>stathamae</i> Cazier	<i>Myrmecocystis mimicus</i> Wheeler <i>Novomessor cockerelli</i> (E. André)	Arizona Arizona	New Record Cazier
<i>mentalis</i> Cazier	<i>Novomessor albisetosus</i> (Mayr) <i>Pogonomyrmex maricopa</i> Wheeler <i>Pogonomyrmex barbatus</i> (F. Smith) <i>Dorymyrmex pyramicus</i> (Roger)	Arizona Arizona Arizona	Cazier Cazier Cazier
<i>beameri</i> Cazier	<i>Pogonomyrmex barbatus</i> (F. Smith)?	Arizona	Cazier
<i>lengi</i> Cazier	<i>Myrmecocystis mimicus</i> Wheeler?	Arizona	Cazier
<i>constricticollis</i> Cazier	<i>Myrmecocystis mimicus</i> Wheeler <i>Pogonomyrmex barbatus</i> (F. Smith)?	Arizona	Cazier Cazier
<i>Genuchinus</i> <i>ineptus</i> Horn	<i>Formica obscuripes</i> Forel <i>Crematogaster coarctata</i> Mayr <i>Liometopum occidentale</i> <i>luctuosum</i> Wheeler	Arizona Arizona	Wenzel Cazier New Record

Phil Bagwell we extend our thanks for allowing us to dig holes on his property, stake out the plot and leave our markers in place indefinitely. Without such generous cooperation studies such as this one would of course be impossible.

The paucity of behavior and biological information in the genus *Cremastocheilus* is especially evident in the *Trinodia* section which are relatively uncommon in collections. With one known exception, no species in this section of the genus have previously been found in sufficient numbers in any one locality with their ant hosts to allow for a detailed study. In 1958 the senior author located a large population of *C. mentalis* Cazier associated with 4 species of ants (Cazier, 1961) but was unable to spend sufficient time in the area to get much information. A return trip to the locality was planned for 1959 but before this was accomplished the large population of *C. stathamae* Cazier was found conveniently located only 7.5 miles from the Southwestern Research Station near Portal, Arizona. In spite of a heavy population of punkies co-inhabiting the area, the ants and the *Cremastocheilus* were observed every day for 42 consecutive days for their entire active period during each day. The plot was further checked occasionally in 1960 and 1961 and the activity and behavior appeared to be the same as that observed in 1959 and the beetles just as abundant.

The first specimen of *C. stathamae* Cazier was collected on August 2, 1959 in a narrow, dry, sandy wash as it was being pulled by a single ant (*Myrmecocystis mimicus* Wheeler) toward the entrance to its nest. The ant was allowed to take the beetle for about 2 feet and get it inside the nest turret before the specimen was collected. A search of the area on the same day by Dr. E. G. Linsley and the authors produced 6 males and 18 females. On August 3, 14 males, 13 females; August 4, 2 males, 2 females; August 5, 1 male, 4 females; August 6, 1 male, 1 female; and on August 7, 4 males, 8 females. On August 8 we stopped killing the specimens, staked out the ant nests, started marking the beetles and continued making detailed observations.

The area in which these observations were made is located 2.5 miles northeast of Portal, Arizona, on the road to San Simon at an elevation of about 4700 feet. The study plot, which was located about 200 feet east of the road, extended for about 246 yards east and west by 204 yards north to south. It was situated

on an aluvial fan formed by a small wash which was usually dry but evidently carries considerable water during the rainy season. The drainage is from the foothills of the Chiricahua Mountains. The surface covering consisted primarily of silt, sand and soil in a layer of from 0 to 12 inches, underlaid with caliche. The southwest corner of the plot was somewhat rocky, especially in the

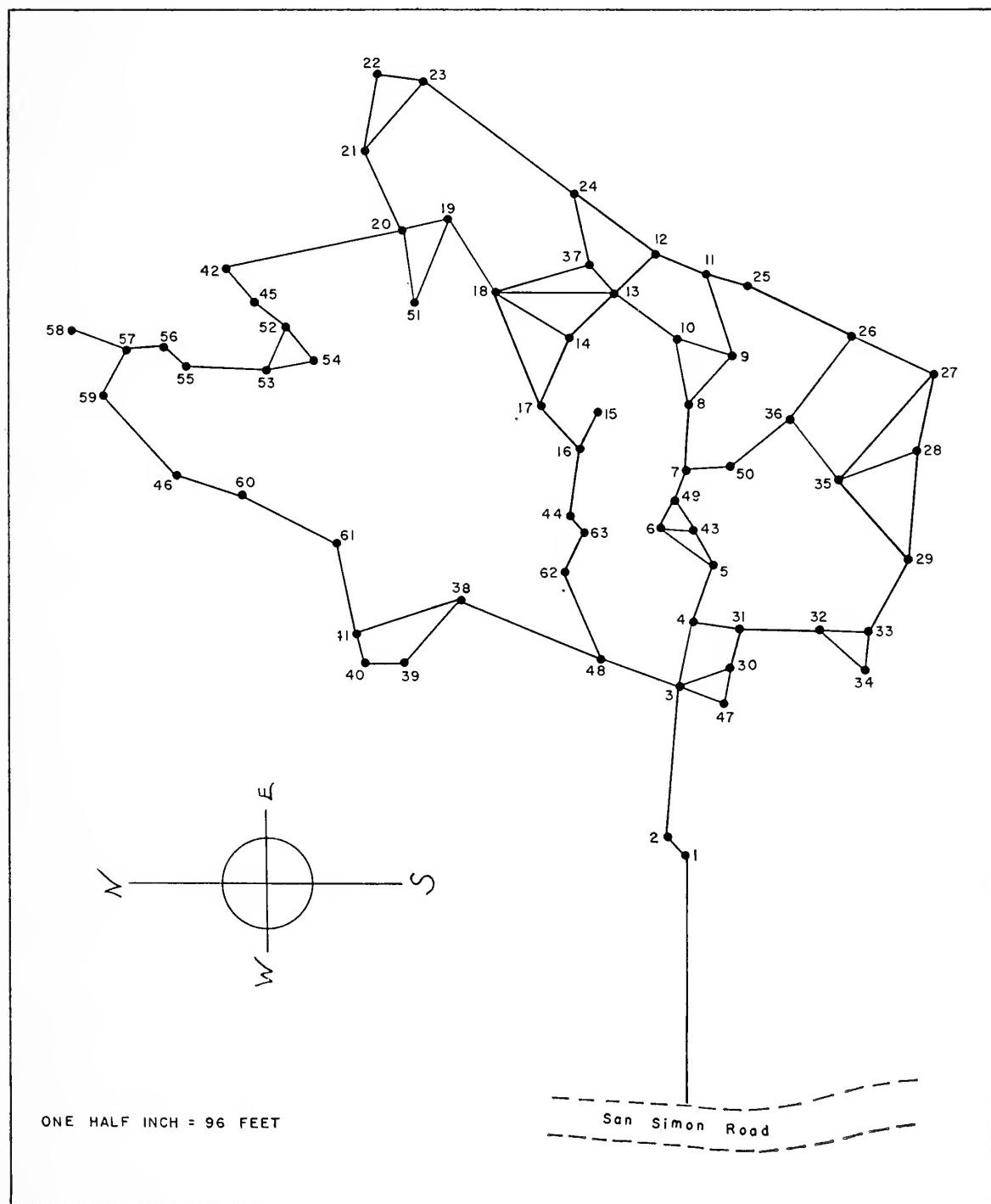


FIG. 1. Map of study plot showing relative location of the *M. mimicus* nests.

vicinity of the main wash, and the entire plot was traversed by small, shallow, sandy side washes.

The principal vegetation cover consisted of tar-bush, *Flourensia cernua* D.C. which is a small shrub with a hoplike odor, bitter taste and is unpalatable to livestock. In the northern half of the plot the tar-bush was mixed with an open stand of Creosote-bush, *Larrea tridentata* (D.C.), which also has a strong characteristic odor and is seldom eaten by livestock. The predominance of these two plants was probably the reason why we were not bothered by cattle feeding on this open range. There were scattered plants of *Yucca elata* Engelman, Mesquite, *Prosopis juliflora* (Swartz) D.C. and a sparse assortment of grasses and composites. Most of the ground between the primary plant shrubs was clear of vegetation cover and this is where the majority of the *M. mimicus* Wheeler ant colonies were located.

On August 8 discarded pieces of molding, 3–6 feet long were taken to the plot to serve as stakes and old pieces of white cloth to serve as flags. A stake was placed in the tar-bush nearest each ant colony that had been observed from August 2–7 inclusive and then other colonies in the area were given the same treatment until a total of 63 were marked. Late in September it was discovered that there were about 30 additional colonies that had either been missed or were new ones. Each stake had a white strip of cloth tied on top and each was given a number. Ten small bottles of paint were part of the equipment with which to mark the beetles and the stakes. The paint used was Testors Dope, a model airplane paint, that dries very rapidly, has good lasting qualities and apparently does not harm the beetle if kept on the elytra. The presence of the paint spots on the beetles did not appear to disturb the ants. Three test spots of different colors painted on a small pebble at the entrance to nest number 13 in August of 1959 were just as bright as ever in April, 1961 in spite of the ants and the heavy winter rains and winds that occurred in the area. As the beetles were marked, the same color combinations were put on the stakes with an O to indicate that the beetle was being taken out of the nest and an X if he were being taken into the ant colony. This information was also recorded in notebooks along with other observations. To avoid any confusion that might result in distinguishing shades of colors, 10 of the most distinct were used as follows: white, pale

yellow, dark yellow, green gold, silver, pale blue, dark blue, orange and red. The first 10 beetles marked were given single spots of color on the right elytron, right being as the beetle faced away from the marker, and all subsequent markings involved different combinations of colors using both elytra. A total of 51 beetles were marked with different combinations and released.

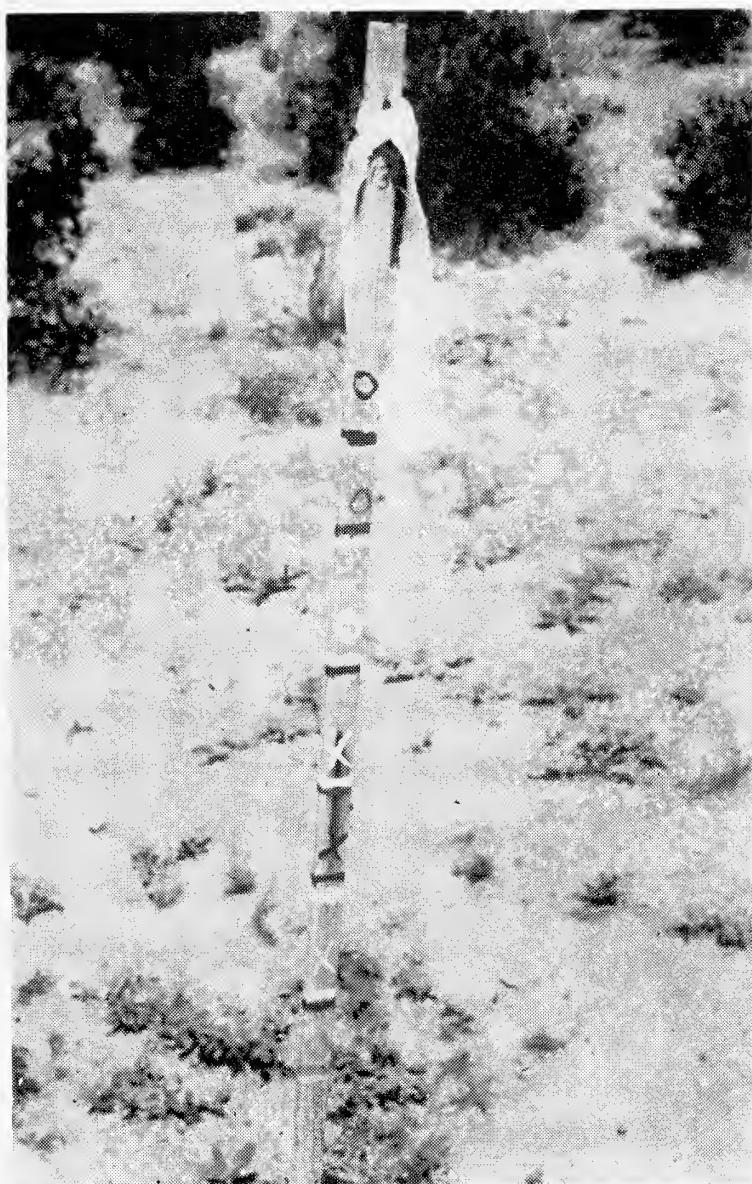


FIG. 2. Stake marking nest no. 13 showing the method of indicating the number of beetles being brought into or out of the nest and the color combinations used on each.

It was soon evident that beetle activity was in large part dependent on the activities of the ants which in turn were definitely adjusted to the climatic factors of sunlight, temperature, moisture and wind. Also, raiding columns of *Dorymyrmex pyramicus*

(Roger) would rather completely change the behavior pattern of a colony of *M. mimicus* Wheeler. The close relationship between the ants and the beetles necessitated the careful observation of both. One of the most interesting and characteristic features of the genus *Myrmecocystus* (Honey ants) is that in at least some species certain members of the colony are converted into living bags of honey called repletes (Creighton, 1950, p. 437). *M. mimicus* Wheeler was one of the species in which repletes were unknown, which caused Wheeler to create some systematic confusion (Creighton, 1950, p. 448). Exploratory excavations of three *M. mimicus* Wheeler colonies on the plot proved without doubt that they do produce repletes at least in this location. In the first colony they were found in chambers at about 3 feet from the surface, in the second at about 3 and $\frac{1}{2}$ feet and in the third at slightly over 4 feet. These excavations were made in an attempt to get information on the beetles behavior below ground but the only information gained was that one specimen was taken from the first nest at about 14 inches from the surface. Additional studies are planned to secure information on the beetles behavior and biology within the colony. All three of the excavations were filled in with loose dirt and all three colonies were active again on the surface within about a week. On September 1 the second colony, excavated sometime between August 5 and 10, brought out an unmarked beetle.

As mentioned, previously, most of the *M. mimicus* Wheeler colonies are located in the open areas between plants. Each nest is characterized by having a more or less rounded crater with variously shaped holes in the center. The craters are made up of small or medium sized pebbles and soil, surrounded on the outside by discarded pieces of plants, insects and other debris. Measurements on the hole diameters were made on 42 colonies taken at random with the following results:

19 asymetrical holes	23 symetrical holes		
East-West	North-South	East-West	North-South
average	.92 inches	.92 inches	.84 inches

These figures indicate a slight correlation between size of hole and exposure. The east-west measurements in both cases are larger which means a longer exposure to sunlight. In 10 measurable turrets surrounding asymetrical holes the average

diameter was 7.17 inches, in 17 symetrical holes the average diameter was 6.22 or almost an inch smaller. The measurements were made to the outside of the crater limits. In only two or three instances were there 2 entrances to a single ant colony and these were close together, within 2-7 inches of each other.

Because of the density of the *M. mimicus* Wheeler colonies in the study area the distances between the colonies were measured to determine any spatial or territorial relationships that might exist. The minimum measurement was 14 feet between colonies 1 and 2 with an intervening small wash. The next closest colonies 6 and 49, were 18 feet apart with no intervening wash. The maximum distance was 132 feet separating colonies 23 and 24 and the average distance between colonies was 49 feet. There seems to be no set spatial requirements for this species of ant and no readily observable factors that might have determined the location of the nests.

Several factors affected the behavior of *M. mimicus* Wheeler so that no beetles were being brought into or out of their nests:

1. Rain and cool weather usually either stopped ant activity altogether or confined it to bringing debris out of the nest and depositing it on the sides of the crater.

2. Raids by *Dorymyrmex pyramicus* (Roger) would stop all outside activity and the *M. mimicus* Wheeler workers would stay inside the nest entrance or occasionally bring a piece of debris out onto the side of the crater and then quickly retreat inside again.

3. Winds strong enough to carry sand or debris along the surface of the ground would keep the ants busy carrying these materials out for deposition on the crater walls.

4. Rains that carried materials into the nest opening would also cause these "clean out" activities.

5. Excessive heat would stop all outside activities even those involving "clean out".

On hot sunny days it was observed that if a shadow was over the nest entrance of an inactive ant colony for a few minutes the ants would become active and start foraging activities. On August 10 several cardboard boxes with two sides cut out were taken to the plot. At 9:30 A.M. a box was placed over colony number 3 which was inactive and at 9:42 A.M. they began bring-

Table 2

Date Aug.	Period of Beetle activity	Weather Conditions	Number of Beetles		Temperature (F.) and Rainfall recorded about 2 miles away				
			IN-	OUT	Rain	6 A.M.	12 Noon	6 P.M.	12 Mid.
2	11:30- 4:05	Warm, Sunny	4	10	Trace	68	93	80	78
3	9:15- 4:40	Rain night before, ground damp	6	7		78	98	90	80
4	9:05- 2:35	Cool, Sunny	1	1		72	72	82	75
5	9:05- 2:36	Partly cloudy	2	4		72	90	90	75
6	4:05- 4:25	Rain		2	1.00	73	90	80	74
7	9:55- 3:35	Very damp, sunny, occasional clouds, light breeze	3	9	.60	72	94	90	76
8	2:30- 3:30	Damp, cool	1	8		73	74	81	71
9	10:00- 1:45	Cloudy, threatened rain		1		71	95	75	70
10	9:42- 1:15	Hot, sunny	2	1		78	94	88	77
11	11:00- 2:40	Heavy rain night before, cloudy most of day	4	5	.30	74	80	80	73
12	10:03- 3:45	Scattered clouds, light showers, hot and humid		2	.10	73	94	90	78
13	11:30-11:55	Overcast, threatened rain, strong breeze, chilly	2	7		76	90	75	70
14	11:15-12:50	Mostly overcast, warm and humid		4		70	90	90	74
15	1:20- 3:15	Heavy rain night before, light rain in morning, over- cast	1		.40	72	96	96	77
16	10:05- 1:00	Sunny in morning, overcast in after- noon	1	2		73	96	82	76
17	None	Sunny in morning, afternoon cloudy, strong breeze				74	96	83	73

ing a beetle out of the nest. However, he was not out by 12:10 P.M. so the box was taken off and at 2:05 P.M. they were successful in getting one out. A second box was placed over colony number 31 at 9:35 A.M. and they started foraging activities. At 9:45 A.M. they were bringing a beetle in from 15 feet away from the entrance. During these periods when the outside activities of the ants were limited there was no observed beetle activity either at the nest entrance or away from it. On one or two occasions, after ant activities had ceased for the day,

Table 2—(continued)

Date Aug.	Period of Beetle activity	Weather Conditions	Number of Beetles	Temperature (F.) and Rainfall recorded about 2 miles away						
				IN-	OUT	Rain	6 A.M.	12 Noon	6 P.M.	12 Mid.
18	10: 05	Sunny, occasional clouds, dry, strong breeze	1		.30	71	86	86	72	
19	None	Cloudy, rain, cool			.20	70	84	75	70	
20	None	Cool, overcast, light breeze				67	79	83	70	
21	9: 50–12: 35	Rain night before, warm, some overcast	2			70	84	76	70	
22	11: 20– 2: 50		2	2	.30	70	86	87	74	
23	None	Sunny, scattered clouds, light breeze				71	91	—	—	
24	2: 25	Rain night before, sunny, scattered clouds, strong breeze	1			—	—	—	—	
25	None	Overcast, rain off and on				—	—	—	—	
26	10: 30	Rain day before, morning hot, sunny	1			—	—	—	—	
27–31	None									
Sept. 1	9: 30	Clear, sunny, dry	1							
2–9	None	Sunny, breezy, very dry								
10	9: 45–10: 15	Rain night before, overcast, breezy	1							
11	9: 20–12: 40	Sunny, scattered clouds, light breeze	4							
12	10: 30– 1: 20	Sunny, breezy	1							

beetles were found sitting on the ground away from any nest apparently "waiting" to be picked up by the ants. They had probably been ejected from nests during the preceding active period and there hadn't been time for the ants to find them before one of the above listed factors stopped their foraging or swarming activities. No beetles were observed being ejected from the colonies when the ants were only engaged in "clean out" activities. If the beetles were considered by the ants to be foreign objects or used prey one would assume that this would

be the time when most of the beetles would be expelled from the colonies. Apparently the ant is motivated by some other factors in the expulsion of the beetle or the colony has to be in a more excited state, as they seem to be during foraging or swarming.

Maximum periods of activity occurred in general when it had rained the night before and the temperature range was between 80° and 98° F. or on overcast days when rain was threatening but temperatures were high. During these periods the ants would send out directional foraging column's consisting of many individuals or single individuals would wander about in all directions. It was during the latter type that most if not all of the beetles were located and were being brought back to the nest. At the same time there would be considerable activity around the nest opening and beetles would be brought out. During the 42 days of observation on the plot the earliest ant and beetle activity started at 9:05 A.M. on August 4 and the latest activity occurred on August 6 with the capture of the last beetle at 4:25 P.M. The starting time and duration of activity was of course dependent on the various conditions previously mentioned.

Table two shows the time limits of beetle activity, the prevailing weather conditions during this period, the number of beetles being brought into and out of the ant nests and the rainfall and temperature according to date.

Of the 32 specimens of *C. stathamae* Cazier that were observed being brought into the nests by *M. mimicus* Wheeler only 4 of them involved more than one ant. In all other cases one ant would have its mandibles fastened to the upturned portion of the beetles clypeus and would either be leading it to the nest or on several occasions the beetle was between the ant and the nest walking or running backward or sideways. When 2 ants were involved, the second would usually have hold of a leg but would let go occasionally and sometimes leave. When one ant was involved the route followed to the nest was fairly direct, but when a second ant interfered the route was more erratic. The distances involved varied from 1 to 20 feet and if no obstacles were encountered they traveled at a rate of about 1 foot a minute. In one case it took an ant only 20 minutes to bring a beetle 18 feet to the nest through rocky ground. With few exceptions the beetles helped in getting to the nest as can be deduced by the short travel time involved and the fact that a single ant could not move a beetle unless assisted since the beetles

by bulk are about 10–15 times the size of the ant. In another case a beetle was always in front of the ant while they traveled 15 feet to the nest. Eight ants from a colony, that was later excavated, brought a beetle out of their nest, dragged it 5 feet away at which point all the ants released their holds and some started back toward the nest. The beetle upon being released went straight back into the nest unassisted, getting there ahead of the ants who had pulled it out.

Unlike several other species that have been reported on in the past *C. stathamae* Cazier apparently does not fly directly into the immediate vicinity of the ant nest and those being brought in were observed from 4 or more feet away from the nest. Even those at 4 feet may have been individuals ejected from the nest and taken away to that distance by the ants before being released.

During the period when these observations were made the ants were carrying primarily animal booty back to the nest. None were seen feeding on or gathering pollen, nectar, or honeydew. Random samples of this booty contained the following:

Hymenoptera

Remains of several wasps.

Whole but dead *Novomessor cockerelli*.

One live bee.

Orthoptera

Several grasshopper nymphs.

Grasshopper abdomen full of eggs.

Neuroptera

Pieces of Myrmelionid adults.

Hemiptera

Numerous whole, dead and alive, Cydnidae.

Pentatomidae, whole.

Phymatidae, whole.

Lepidoptera

Moth adults, pupae and larvae.

Coleoptera

Curculionidae, dead and alive.

Scarabaeidae, dead and alive.

Tenebrionidae, dead and alive.

Coccinellidae, dead.

Buprestidae, dead.

Meloidae, dead.

Alleculidae, dead.

Diptera

Pupa

Phalangida

Pieces and whole dead ones.

There were also occasional pieces of feathers, seeds, leaves and flowers

These booty samples would seem to lend support to the explanation that the *Cremastocheilus* are brought in as food during normal foraging activities. This may in part be the case but such a simple explanation leaves unanswered a number of questions that enter into the relationship. 1. Other live booty being brought in offers resistance and more than one ant is usually involved in getting it to the nest. 2. The *Cremastocheilus* usually offers no resistance and on numerous occasions seems to be pulling the ant toward the nest, the ant serving as a sort of rudder. 3. Only one ant usually takes the *Cremastocheilus* to the nest and where two ants become involved progress is actually



FIG. 3. Adult *C. stathameae* being pulled toward a nest by two workers of *M. mimicus*.

impeded. 4. Some of the pieces and occasionally whole dead specimens of other booty end up around the outside of the crater. 5. No parts or whole dead specimens of *Cremastocheilus* are to be found scattered outside the nest entrance. 6. The only living things observed being brought out of the ant nest and "purposely" released is the *Cremastocheilus*. The beetles are found during normal foraging activities for prey but at this point the ant makes no attempt to kill, mutilate or eat the specimen as it

does with other live booty. It assumes the role of host and guide to the nest.

In October and November of 1960, on a study plot located a half mile away, these ants were feeding on or gathering the pollen and nectar from at least two plants, *Parthenium incanum* H.B.K. and *Euphorbia albomarginata* Englm. and may have been getting honey-dew from a species of Aphid which is abundant on the underside of the leaves of the latter plant. During August and September they were observed on many

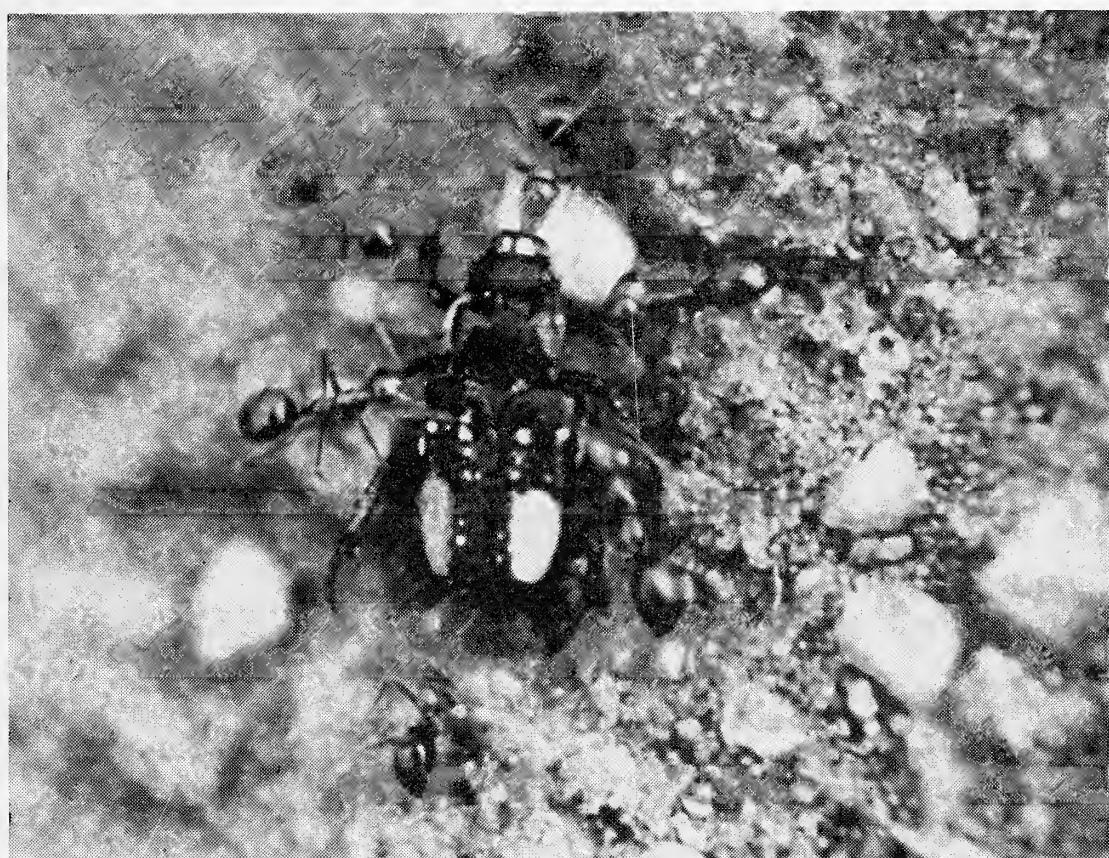


FIG. 4. Marked adult of *C. stathamae* being ejected from the nest by 6 workers of *M. mimicus*.

occasions carrying animal booty and were not found on flowers even though the above plants and *Zinnia pumila* Gray, *Baileya multiradiata* Harv., *Verbesina encelioides* (Cav.), *Gutierrezia microcephala* (D.C.) and *Orobanche fasciculata* var. *lutea* (Parry) were abundant and in full bloom around the nests. It may be that in late fall the ants fill the repletes with nectar and honey-dew as a winter supply of food or they might be filling a newly developed batch of repletes for this purpose. The repletes present in the colonies excavated in August of 1959 were

full even though the ants were apparently gathering only animal booty at that time.

A total of 76 beetles were observed being brought out of the nests by the ants and the behavior pattern of the beetle toward the ants is in contrast to that exhibited when it is being brought in. Also many things happen to amuse the observer and the behavior is more complicated. In most of the nests it was possible to look into the opening for an inch or two and occasionally see a group of ants attached to the legs of a beetle working it upward toward the nest entrance. This often took considerable time and the efforts of from 6 to 8 ants on the average. The beetle would either hold onto the sides of the burrow with the legs that were not being held by ants, wedge itself into cracks or under small projections or try to get further back down into the nest. Once the ants were successful in getting the beetle out of the hole and over the crest of the crater they would drag it for from 1 to 9 feet from the nest but usually only 4 or 5 feet. As progress was made away from the nest the ants would drop off one or two at a time until the beetle was left alone. When the distances were long and the ants attached few, the beetle would assist by walking, once they were away from the immediate vicinity of the nest. When the beetle was deserted by the ants its usual reaction was to fly but there were variations in this behavior as can be seen from the following descriptions.

On August 2 at 3:40 P.M. a beetle was pulled out of a colony by 6-8 ants, one on the clypeus and the rest on the legs. It was about 5 and a half feet from the nest where all but one ant deserted, whereupon the beetle dragged the single ant back into the nest.

On August 4 at 2:35 P.M. 7-8 ants brought a beetle out of their colony and left it about a foot from the nest. The beetle walked away another 2 feet where it was picked up by the large *Novomes-sor cockerelli* (E. Andre) that started off toward its nest. Within a few feet the *N. cockerelli* (E. Andre) tried to cross a column of *Dorymyrmex pyramicus* (Roger) and was attacked. It dropped the beetle which walked about 2 inches and flew. The *N. cockerelli* (E. Andre) succumbed to the attack of the *D. pyramicus* (Roger) as they were seen to do on several other occasions even though the latter ant is much smaller.

On August 12 at 1:10 P.M. 5 ants brought a beetle out of colony

number 3 and took it 3 feet away where 2 different ants found it and took it back into the same ant colony at 1:19 P.M.

On August 2 at 2:19 P.M. a beetle was observed being pulled out of a nest by 6 or 8 ants that would repeatedly get him out 1 or 2 inches only to have it go back in.

On August 9 at 10:00 A.M. several ants brought a beetle out and before 3 of them could let go of its legs the beetle flew away with them.

On August 10 at 9:45 A.M. a single ant was bringing in a beetle from 15 feet away. They arrived at the nest at 9:49 A.M. where the beetle was given a silver spot before disappearing into the colony. At 10:09 A.M. it was being brought out again but managed to get back into the nest. Between 10:09 and 10:45 A.M. silver was brought out but got back in 8 times. Up to 12:10 P.M. it was still in the nest.

On August 11 colony number 13 brought beetles out at 11:20, 11:25 and 11:40 A.M. At 12:20 P.M. they were dragging an unmarked beetle toward the nest but after being marked it got away from the ants and flew. Also at 12:20 P.M. they were given a beetle that was found nearby and after taking it into the nest for a few minutes brought him out and it flew away.

On August 11 at 2:05 P.M. an ant from colony number 9 was found bringing in a beetle. It was in the colony only a few minutes when 6 or 8 ants brought it out and with its help took it about 5 feet from the colony where all the ants left it. A single ant, not one of the group that escorted it out, found it and with its help took it back into the colony. At 3:15 P.M. this same beetle was found on the ground about 100 feet from the colony.

Although as a general rule the beetles did not appear to want to leave the ant colony there were 2 or 3 cases where they actually helped the ants get them out and then flew at the earliest possible moment. On September 12 a female beetle came out of colony number 39 very rapidly and flew as soon as she was marked.

The concerted effort on the part of the ants to get the *Cremaстocheilus* out of the nest and the beetles usual obvious reluctance at being ejected would lend support to Wheelers conclusion (1908, p. 75) that they are persecuted intruders (*Synechthrans*) that may eventually become indifferently tolerated guests (*Synoeketes*). The only other explanations that can be offered at the moment, without evidence to support them, is that the ants

Table 3

<i>Ant Colony number</i>	<i>Beetle brought in</i>	<i>Beetle brought out</i>	<i>Left Elytron</i>	<i>Markings</i>	<i>Right Elytron</i>
3		Aug. 10		Dark blue	
		Aug. 12	Pale blue	White	
		Sept. 11	White	Dark yellow	
4		Aug. 12	Orange	Pale blue	
5	Aug. 22		Orange	Dark blue	
6		Aug. 8		Pale blue	
		Aug. 13	Pale blue	Gold	
7		Aug. 9		Orange	
		Aug. 11		Pale yellow	
8		Aug. 14	Dark yellow	Pale blue	
		Aug. 22	Orange	Pale yellow	
9		Aug. 8		Green	
	Aug. 11		White	Orange	
	Aug. 11		White	Pale blue	
10		Aug. 22	Orange	White	
12		Aug. 14	Pale blue	Dark yellow	
13		Aug. 11	Pale blue	Red	
		Aug. 11	White	Green	
		Aug. 11	Red	White	
	Aug. 11		Green	White	
	Aug. 11		White	Red	
	Aug. 12		Green	Pale blue	
15		Aug. 14	Pale blue	Silver	
16		Aug. 13	Pale blue	Dark blue	
		Aug. 13	Gold	Pale blue	
17	Aug. 13		Pale blue	Pale blue	
21		Aug. 11	Red	Pale blue	
		Aug. 14	Silver	Pale blue	
23	Aug. 18		Orange	White	
		Sept. 11	White	Pale yellow	
28		Aug. 8		Dark yellow	
	Aug. 10			White	
29	Aug. 15		Dark blue	Gold	
30		Aug. 12	Pale blue	Green	
31	Aug. 8			Red	
	Aug. 10			Silver	
32	Aug. 13		Dark blue	Pale blue	
37		Sept. 1	Red	Dark yellow	
		Sept. 10	Red	Orange	
39	Aug. 12		Pale blue	Orange	
		Sept. 12	Orange	Red	
42		Aug. 16	Pale blue	Pale yellow	
	Aug. 22		Pale yellow	Green	
43	Aug. 16		Pale yellow	Pale blue	
44		Aug. 16	Dark blue	White	
		Aug. 24	Green	Pale yellow	
		Aug. 26	Red	Pale yellow	
45		Aug. 21	Red	Dark blue	
46		Aug. 21	Orange	Green	
56		Sept. 11	Red	Green	
59		Sept. 11	White	White	

eject the beetle during its breeding season or that the beetle becomes an obnoxious guest at some point in the development of the ant brood. Specimens of *C. knochi* LeConte were reported by Lugger (1891) as mating in an open field but to date we have been unable to observe any mating activity in *C. stathamae* Cazier in spite of their abundance. Horn (1871) reported finding *C. schaumi* LeConte and *C. angularis* LeConte apparently eating ant pupae and Howden (in lit.) has found *C. armatus* Walker feeding on ant larvae. Such activities might cause their expulsion by the ants.

Table 3 contains the number of the ant colony, the beetles and the dates on which they were being brought in or out of the ant colonies and the color markings given each specimen. It covers the dates between August 8 and September 12, 1959.

The primary purpose of marking individual beetles was to be able to trace the movements of each to see how far they traveled, whether or not they were confined to a single colony of ants, and to be sure the same individual wasn't being recorded many times. Unfortunately only 4 recoveries were made during the 42 days so the data is limited.

On August 11 at 2:05 P.M. at colony number 9 a beetle was marked white on the left and pale blue on the right elytron and at 3:15 P.M. the same day it was found on the ground about 100 feet from colony number 9.

On August 8 between 2:30 and 3:30 P.M. a beetle coming out of colony number 6 was marked pale blue on the right elytron. Seven days later on August 15 this same individual was being brought out of colony number 11 which is located some 174 feet from number 6.

On August 15 at 3:15 P.M. a female beetle was brought into colony number 29 during a nuptial flight of the ants. The specimen was marked dark blue on the left and gold on the right elytron. On the following day at 11:35 A.M. this female beetle was being brought out of colony number 11 which is about 294 feet from colony 29.

On September 10 a female beetle was brought out of colony number 37 at 10:15 A.M. and after being marked red on the left and orange on the right elytron was taken back into the colony. On the following day the same beetle was brought out of the colony at 12:40 P.M. and flew away going west.

From these limited observations it would seem that the beetles are not confined to any given colony of ants and they do travel considerable distances. The latter fact might in part be responsible for the poor recovery record. Also their flight is rapid and difficult to follow.

In order to insure the least amount of disturbance in marking the beetles the incoming specimens were allowed to get inside the crater before being picked up. They were replaced in the same spot. The outgoing beetles were allowed to go until deserted by the ants and were ready to fly. They were then picked up, marked, and replaced in the same spot.

C. stathamae Cazier is also associated with the ant *Novomessor cockerelli* (E. Andre) or at least individuals were picked up by these ants and taken to their colonies. However, it is doubtful that the behavior pattern is anything like that shown with *M. mimicus* Wheeler since *N. cockerelli* (E. Andre) is so large that a single ant can pick the beetle off the ground and carry it. On September 10 a *N. cockerelli* (E. Andre) carried a dead *C. stathamae* away from the vicinity of colony number 51 and went 28 yards in 15 minutes carrying the beetle upside down most of the way. On several occasions the very small ant *Forelius foetidus* (Buckley) was seen crawling over and around a *C. stathamae* Cazier that was not moving. On August 7 at 12:20 P.M. a beetle was being brought out of a *M. mimicus* Wheeler nest by 5 or 6 of these ants but there were also 2 *F. foetidus* (Buckley) next to the entrance hole seemingly trying to help.

In most of the published literature referring to members of the genus *Cremastocheilus* the statement is made that the ants keep the beetles captive in order to "milk" them of the fluids that exude from the pubescent glandular areas located beneath or at the front and hind angles of the pronotum. The beetles have such a structure that may be glandular and some specimens show signs of having the angles of the pronotum chewed upon, presumably by the ants in their attempts to get at the glands beneath. If such is the case then in *C. mentalis* Cazier and *C. stathamae* Cazier these "milking" activities must be confined entirely or in large part to behavior within the nest. In field observations involving over 70 specimens of each species no ants were observed to concentrate on these areas of the beetle and were trying primarily to get the beetle into or out of the nest. In

C. stathamae Cazier the beetles are certainly not held captive all the time since two-thirds of the behavior observations given above were made on specimens being "forcibly" ejected from the nests by the ants.

Although *C. stathamae* Cazier was the predominant species of *Cremastocheilus* in this area, specimens of 2 other species were taken; *C. lengi* Cazier and *C. constricticollis* Cazier. They are, however, distinct species. *C. lengi* Cazier is the only member of the genus having 4-segmented tarsi and *C. constricticollis* Cazier is the only species having the pronotum only slightly more than one-half as wide as the elytra. Both species were found in association with *Myrmecocystis mimicus* although none were observed being taken in or out of the nest in 1959.

The plot was checked the middle of February 1960 and occasionally thereafter but there was no ant activity until the early part of June. The junior author checked on them July 22 and found 2 males and 10 females being brought out of colonies between 9:55 A.M. and 1:20 P.M. All the beetles were unmarked and were from colonies 5, 9, 13, 14, 16, 47, 49, 53 and 2 unlabeled colonies. The 11th female was out on the open sand between colonies. The area was checked twice in September and the beetles and ants were still active. Colonies 5, 9, 13 and 16 were active in 1959 but this record is the first for colonies 14, 47, 49 and 53.

On April 22, 1961 a *C. stathamae* was found being taken toward a nest by a single specimen of *M. mimicus* but their course was erratic because the ant was holding the beetle by the left front leg. The beetle was doing most of the propelling and being off balance much of the motion was circular. In 45 minutes they traveled about 20 feet and although they came within 6 or 8 inches of the nest several times the ant was not able to get the beetle in and finally deserted it. The beetle remained motionless for about 15 minutes and was then placed just inside the nest crater. Only 2 or 3 ants had been seen at the nest up to this time when 10 or 12 rushed out of the hole, seized the beetle and disappeared into the nest. The beetle was not observed being ejected during the next hour.

In addition to these observations on *C. stathamae* Cazier the junior author took 2 old (badly rubbed) but live specimens of

C. constricticollis Cazier. One male was being taken into colony 32 by 3 ants at 10:55 A.M.

There are several other interesting side lights to the main study but these will require additional observation and laboratory work. On a number of occasions small bee flies, Bombyliidae, were seen hovering over the *M. mimicus* Wheeler nests, dipping down now and then over the hole and dropping the abdomen as if putting eggs into the ant burrow. When a jar of preserved material excavated from a *M. mimicus* Wheeler nest was examined a medium sized dipterous larva was present.

On September 11, 5 case bearing larvae were found at the entrances to the *M. mimicus* Wheeler burrows. Two were taken just inside the crater of the colonies, 1 was just coming out of the entrance, 1 was being dragged out of colony number 16 by 2 or 3 ants and the fifth was on the side of the crater with 2 ants trying unsuccessfully to dislodge him. Three specimens were collected for rearing but as yet are still in the larval stage. They are probably the case bearing larvae of the Chrysomelid genus *Saxinus* and if so they may be the larvae of any one of about 6 species recorded from Arizona.

Summary

1. Myrmecophilous scarab beetles in the tribe Cremastocheilini from North America have been found associated with ants belonging to 11 genera.
2. The true relationship between members of the genus *Cremastocheilus* and its ant hosts is undetermined.
3. It is suspected that different species in this genus are at various stages in the evolution toward complete symbiosis with the ants.
4. *Cremastocheilus stathamae* Cazier at a location 7.5 miles from the Southwestern Research Station is a willing guest of the honey ant *Myrmecocystis mimicus* Wheeler.
5. This ant assists the beetle into the nest and then for some undetermined reason expels it. This may occur within minutes or days and possibly months after its entrance into the nest.
6. During several summer months *M. mimicus* Wheeler brings animal booty into the nest almost exclusively. In October and November they also bring in nectar and possibly honeydew presumably for winter storage in the repletes.

7. *C. stathamae* Cazier is not confined to a single colony and travels for considerable distances. It is also associated with the ant *Novomessor cockerelli* (E. Andrea).
8. *C. constricticollis* Cazier and *C. lengi* Cazier are also guests of *M. mimicus* Wheeler.

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ENTOMOLOGISTS ON THE MOVE

Professor A. H. MacAndrews, a forest entomologist of note, has retired as Chairman of the Department of Forest Entomology at Syracuse University. With Boulder, Colorado as his new address, he plans to cooperate with the federal and state agencies on a special Black Hills Bark Beetle control project. It is also his intention, now that he has "retired," to begin a collection of Colorado forest insects of importance.

Dr. Mont A. Cazier, formerly Resident Director of the Southwestern Research Station of the American Museum of Natural History, Portal Arizona is now associated with the Department of Entomology and Parasitology of the University of California at Berkeley.

EFFECTS OF PARENTAL AGE ON THE LIFE CYCLE OF THE HOUSE FLY, *MUSCA DOMESTICA* *LINNAEUS* (DIPTERA: MUSCIDAE)¹

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ABSTRACT

A parental age study of 2 strains of house flies, *Musca domestica*, was undertaken. In the CSMA strain 18 consecutive generations, from the first eggs laid in each generation, and 2 consecutive generations from the parental, the F_2 , the F_4 , and 3 from the F_9 , obtained from the last eggs laid, were studied. In the Wilson strain, 12 consecutive generations from the first eggs laid, 9 from middle-aged parents, and 6 from old (18 days) parents were studied at 25° C., under constant conditions of lighting.

There was no parental age effect on the duration of the preimaginal stages, the larvae and the pupae each requiring 6 days. A reduction in the survival time occurred for adults of both strains when the first eggs laid in successive generations were selected. The use of the last viable eggs in the CSMA strain resulted in a decreased longevity and a reduction in reproductive capacity. No more than 3 consecutive generations could be reared.

Adult flies, at the age of 0, and 6 days, from both young and old parents were kept at different humidities without food. Those from young survived longer than those from old parents.

Parental age effects have been described by various investigators. Comfort (1953), using the vinegar fly *Drosophila subobscura*, stated that there was no change in longevity through successive generations of offspring obtained from old parents. Goetsch (1956) observed that in *D. melanogaster*, offspring from young lived longer than those from old parents. O'Brian (1961), using the same species, reported that the duration of

¹ From a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the department of Biology at Fordham University. The author wishes to acknowledge gratefully the able direction of Dr. Daniel Ludwig, under whose supervision the work was done.

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the period for viable egg production was longer in offspring from young, than in those of middle-aged or old flies. Rockstein (1957) observed in the house fly, *Musca domestica*, that females from young parents had a greater longevity than those from old, but that male longevity was not effected. In 1959, after further investigations, he reported that males from old had a greater longevity than those from young parents.

Ludwig (1956) discovered in the mealworm, *Tenebrio molitor*, that the longevity and duration of larval life decreased in progeny of old beetles. Using the same species, Tracey (1958), reported that offspring from old had a significantly shorter life and a higher growth rate than those from young parents. Ludwig and Fiore (1960) verified Tracey's work and reported that these effects were not present until the parent beetles were 1 month old. Ludwig and Fiore (1961) studied offspring from isolated pairs and demonstrated that their previous findings were not caused by selection, since the same effects (with the exception of the shortening of adult life) were obtained. Fiore (1959) studying the dark mealworm, *Tenebrio obscurus*, found no consistent parental age effects upon the life cycle, but stated that the larvae from old had a slower rate of growth and failed to attain the same maximal weight as those from young parents.

The present experiment was initiated to determine whether parental age effects appear in the life cycle of the house fly, *M. domestica*, and to study the ability of flies, obtained from both young and old parents, to withstand unfavorable conditions of starvation and low humidity.

MATERIALS AND METHODS

Two DDT-sensitive strains of house flies were utilized, a standard CSMA, and the Wilson strain.³ They were maintained at 25° C., under constant lighting. The adults were reared in metal screened cages, 12 by 12 by 10.5 inches. To prevent over-crowding, less than 100 flies were placed in a cage. The adults were fed diluted sugar water and diluted non-fat, milk, prepared from Borden's Starlac. A wad of absorbent cotton, cov-

³ The CSMA (Chemical Specialty Manufacturers Association) strain was obtained from Dr. Mark Henry, Boyce Thompson Institute for Plant Research, Yonkers, N. Y. The Wilson strain was obtained from Dr. Andrew J. Forgash, Rutgers University, New Brunswick, N. J.

ered by a 5 inch cotton gauze square, was placed in the milk which was then drained from the dish, leaving the saturated pad in the dish. The flies usually oviposited on the cotton pad. Eggs from the CSMA strain were transferred to half-pint culture bottles containing 50 ml. of water and an equal volume of Gaines dog meal. The top of the culture bottle was covered with heavy paper toweling. After 4 days, more meal was added to provide a suitable dry area for the larvae to pupate. Pupae were removed and placed in 50 ml. beakers covered with gauze, where emergence could be easily observed. On emergence the flies were released into cages. Dead flies were removed daily and time of survival and sex of each fly recorded. The flies of the Wilson strain were reared in the same fashion except that powdered Kasco dog pellets were used as the larval medium.

In the CSMA strain, 18 consecutive generations were reared from the first eggs laid in each generation. Two consecutive generations, obtained from the last viable eggs, were reared from the parental, the F_2 , the F_4 , and 3 from the F_9 .

Starting with the parental generation of the Wilson strain, 12 generations were reared consecutively from the first eggs. Nine consecutive generations were reared from eggs laid 5 days after the first eggs; these were called offspring from middle-aged parents. Finally, 6 consecutive generations were reared from the largest batch of eggs laid 18 or more days after emergence.

To compare the ability of offspring, from both young and old parents, to survive unfavorable environmental conditions, house flies of the CSMA strain were placed individually in small vials, which had a perforated metal cap. Eight such vials were placed in a 1-pint glass, preserving jar. A volume of 100 ml. of one of the following had been placed in each jar, resulting in the corresponding relative humidity value (Sweetman 1933): anhydrous CaCl_2 , 0; saturated CaCl_2 , 32; saturated NaCO_2 , 62; saturated NaCl , 76; and H_2O , 96 percent. Flies within 2 hours of emergence, never fed as adults, and flies that were 6 days old, and fed as adults, were utilized.

OBSERVATIONS

The period from hatching to the appearance of the first adults was found to be 12 days for offspring from both young and old

parents. This period consisted of 6 days of larval, and 6 of pupal life, using the appearance of the first pupa as the end of the larval, and the emergence of the first adult as the end of the pupal stage. The duration of the egg laying period averaged 15 days, and showed no consistent parental age effect. There was a reduction in the number of eggs laid as the adults aged in offspring from both young and old parents. Towards the end of the egg laying period, batches of viable were interspersed with non-viable eggs, and in both types there was a reduction in the number of eggs per batch. Generally, the eggs that were laid by older flies were less viable than those laid earlier. In most cases only a few larvae hatched from eggs produced by old flies, many of which never pupated, and of

TABLE 1

Group	Females			Males		
	No.	Average Survival (Days)	"t" value	No.	Average Survival (Days)	"t" value
P	45	28.6 ± 4.51		38	26.9 ± 2.07	
F ₁	30	32.7 ± 3.16	0.75	32	27.3 ± 2.22	0.13
F ₂	16	18.7 ± 2.17	1.98	17	16.2 ± 1.00	4.65
F ₃	32	15.7 ± 1.80	2.74	37	15.2 ± 0.76	2.78
F ₉	30	14.7 ± 1.61	2.95	37	18.6 ± 1.18	3.60
F ₁₈	36	12.1 ± 0.91	3.58	30	12.7 ± 0.85	6.17

Average survival times, and the significance between these values, of adults of the parental generation compared with those of the first 3, the 9th, and the 18th generation obtained from the first eggs laid. Values are given with their standard errors.

those that did pupate, very few adults emerged. Fewer offspring survived to adulthood as their parents aged. Hence, consecutive generations of offspring from old parents died out. Thus, the rearing of offspring from old flies was difficult, especially when the last viable eggs were used. Under these conditions, no more than 3 consecutive generations could be obtained.

In the CSMA strain, the average survival time for the adults of the parental generation was compared with those of adults in 18 consecutive generations obtained from the first eggs laid. This comparison for the first 3, the 9th, and the 18th generation is given in table 1. There were no differences for the intermediate generations, hence they were not included. The

survival time decreased, and following the second generation this decrease became significant. Significance was calculated by dividing the difference between the means by its standard error. If this ratio ("t" value) is more than 2, the means are statistically different. Thus, the selection of the first eggs laid proved to be detrimental in that the average survival time of the resulting adults diminished.

TABLE 2

Groups Compared	Females		Males	
	Average Survival (Days)	"t" value	Average Survival (Days)	"t" value
Parental	28.6 ± 4.51		26.9 ± 2.07	
From P				
F ₁	16.3 ± 0.16	2.79	13.7 ± 0.82	6.00
F ₂	12.7 ± 1.30	3.45	16.1 ± 1.08	4.69
From F ₂				
F ₁	15.8 ± 2.75	2.50	16.1 ± 2.12	3.85
F ₂	9.7 ± 0.97	4.17	14.0 ± 0.73	5.86
From F ₄				
F ₁	20.7 ± 2.55	1.54	20.8 ± 3.03	1.69
F ₂	12.3 ± 0.59	3.70	13.3 ± 0.62	6.18
From F ₉				
F ₁	13.9 ± 1.44	3.19	15.2 ± 1.65	4.50
F ₂	13.4 ± 1.54	3.30	12.8 ± 1.11	6.13
F ₃	12.4 ± 1.00	3.60	13.4 ± 1.28	5.62

Average survival times, and the significance between these values, of adults of the parental generation compared with those from old parents from 2 consecutive generations obtained from the parental, the F₂, the F₄, and 3 consecutive generations from the F₉, from young parents. Values are given with their standard errors.

In table 2 the average survival times of adult flies, obtained from the last viable eggs, are compared with those of the parental generation. These values were found to be significantly lower in 6 out of 7 cases. Thus, when the last viable eggs were selected there was a reduction in the duration of adult life.

In the Wilson strain, the average survival times of adults of the parental were compared with those of 12 consecutive generations, using the first eggs laid. This comparison for the 1st, 4th, 8th, and 12th generations is given in table 3. Since the intermediate generations showed no differences they were not included. The females, but not the males, showed a statistical

decrease at the 12th generation. These values of the parental were also compared with those of offspring which developed from eggs laid 9 to 11 days after emergence, through 9 consecutive generations. No significant differences were found for either sex. Similar comparisons for eggs laid 18 days after emergence showed no differences through 6 consecutive generations.

TABLE 3

Group	Females			Males		
	No. of Flies	Average Survival (Days)	"t" value	No. of Flies	Average Survival (Days)	"t" value
P	33	20.3 ± 2.21		28	22.3 ± 2.09	
F ₁	49	22.8 ± 1.74	0.89	38	23.1 ± 1.50	0.33
F ₄	24	22.3 ± 2.80	0.73	22	25.3 ± 2.47	0.64
F ₈	21	16.7 ± 2.97	0.97	25	22.2 ± 3.72	0.02
F ₁₂	48	14.4 ± 1.25	2.36	37	19.4 ± 1.50	1.20

Average survival times, and the significance between these values, of adults of the parental compared with those of the 1st, 4th, 8th, and 12th generations obtained from the first eggs laid. Values are given with their standard errors.

The average survival times for adult flies obtained from young and old parents, and kept at different relative humidities, at 25° C., are compared in table 4. They are significantly higher in 0-day females from young than in those from old parents at each humidity. While those of 6-day females are significantly higher only at 76 and 96%. Comparisons for the survival times of 0-day males showed significant differences at all humidities, except 62%, while with 6-day males a difference appeared only at 96%. Thus, recently emerged house flies from young parents are better able to survive unfavorable conditions than those from old parents.

DISCUSSION

The observation that there were no consistent differences in the duration of the larval and pupal periods of offspring from young and old parents is in agreement with the work of Wilkes, Bucher, Cameron, and West (1948) who stated that the length of the larval and pupal periods of the house fly varied with environment, but under standard conditions remained constant.

Rockstein (1959) also pointed out that in this species the developmental time for the first adults to emerge is always constant. Similarly, O'Brian (1961) reported that in *Drosophila melanogaster*, the age of the parents had no effect on the duration of the preimaginal stages.

The observation that with increasing parental age there is a decrease in reproductive capacity agrees with the work of

TABLE 4

% R. H.	Females						
	From Young Parents			From Old Parents			"t" value
	Age in Days	No. of Flies	Average Survival (Days)	No. of Flies	Average Survival (Days)		
0	0	128	2.12 ± 0.06	36	1.77 ± 0.07	3.8	
	6	128	1.74 ± 0.04	21	1.62 ± 0.10	0.9	
32	0	128	2.15 ± 0.05	36	1.66 ± 0.10	4.4	
	6	128	1.58 ± 0.05	21	1.54 ± 0.10	0.3	
62	0	128	2.62 ± 0.08	36	1.91 ± 0.10	5.4	
	6	128	1.45 ± 0.04	21	1.45 ± 0.10	0.0	
76	0	128	2.54 ± 0.06	36	1.91 ± 0.10	5.7	
	6	128	1.48 ± 0.06	21	1.25 ± 0.09	2.1	
96	0	128	2.53 ± 0.08	36	1.80 ± 0.08	6.4	
	6	128	1.81 ± 0.03	21	1.50 ± 0.10	3.0	
Males							
0	0	128	1.81 ± 0.06	36	1.58 ± 0.08	2.3	
	6	128	1.65 ± 0.05	21	1.45 ± 0.10	1.8	
32	0	128	1.98 ± 0.03	36	1.41 ± 0.08	8.1	
	6	128	1.13 ± 0.03	21	1.29 ± 0.09	1.7	
62	0	128	1.84 ± 0.07	36	1.53 ± 0.09	1.3	
	6	128	1.04 ± 0.04	21	1.20 ± 0.06	1.7	
76	0	128	1.85 ± 0.08	36	1.69 ± 0.08	2.5	
	6	128	1.31 ± 0.04	21	1.20 ± 0.06	1.5	
96	0	128	2.04 ± 0.09	36	1.69 ± 0.09	2.7	
	6	128	1.83 ± 0.07	21	1.58 ± 0.10	2.0	

Average survival time of flies, obtained from young and old parents, exposed to different relative humidities, at 25° C. Values are given with their standard errors.

Richards and Kolderie (1957) who stated that in the milkweed bug, *Oncopeltus fasciatus*, fewer eggs were laid late in the reproductive period and that these had lower viability than those obtained from middle-aged parents. Ludwig and Fiore (1961) reported that in the mealworm, *Tenebrio molitor*, the percentage of viable eggs was lower when obtained from beetles 12 weeks after emergence than in those from younger parents.

The detrimental effect on adult survival resulting from the selection of the first eggs is in agreement with the observations of Richards and Kolderic (1957) who found that fewer eggs were laid early in the reproductive period of the milkweed bug, *O. fasciatus*, and these had lower hatching percentages, weighed less, and had a longer developmental time than those from middle-aged parents. Liles (1961) working on the mosquito, *Aedes aegypti*, reported that offspring from the first batch of eggs had reduced longevities and reproductive capacities than those from 15–20 day old parents.

The detrimental effects on longevity obtained by selecting the last eggs through successive generations concurs with the studies by Goetsch (1956) on *D. melanogaster*. He noted that offspring from old had a shorter length of life than those from young parents. O'Brian (1961), using the same species, reported that the selection of offspring from old parents resulted in a shortening of the adult life within the first two generations over that of flies from middle-aged parents. He also pointed out a reduction in the reproductive period of offspring obtained from middle-aged and old, over that of flies from young parents.

The observation, on offspring from middle-aged and from old parents of the Wilson strain, that there was no reduction in average survival may indicate that the 18-day selection was not late enough to show a parental age effect. However, Comfort (1957) reported that there were no changes in the longevity of *D. subobscura*, which were continually selected from 30-day old parents.

The ability of offspring from young to better withstand unfavorable conditions than those from old parents suggests that parental age may be a factor which modifies ability to survive other unfavorable factors, such as exposure to low temperatures or to insecticides.

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RED FACE DEPARTMENT

In the Journal of the New York Entomological Society, Vol. LXX, No. 2, June 1962, page 67 the fact that both **Dr. Rozen** and **Dr. Rindge** are associated with the American Museum of Natural History was inadvertently omitted.

**PROBLEMS IN USING THE LINCOLN INDEX
FOR ESTIMATING THE SIZE OF ANT COLONIES
(HYMENOPTERA: FORMICIDAE)**

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ABSTRACT

A number of foraging ants in colonies of known sizes were marked and samples of the foraging population were taken at intervals thereafter. The theoretical population of the colony was calculated from the number of marked and unmarked workers obtained in these samples. Under the conditions of these experiments it was shown that about 80 per cent of the ants did not participate in foraging and hence samples of the foraging population cannot be used to obtain estimates of the whole population. Factors affecting foraging by ants are discussed in relation to this mark-release-recapture method of estimating populations.

INTRODUCTION

The Lincoln Index, a method of estimating animal populations, was recommended by Chew (1959) for estimating the size of ant colonies. As used by him the method was to collect and mark a known number of ants from one colony. The ants were returned to the nest entrance and a second sample of workers was taken 24 hours later. For an estimate of the colony size the number of marked and unmarked workers in the second sample were used in the formula

$$\frac{(\text{No. ants in 2nd sample}) \times (\text{Total no. marked})}{\text{Number of marked ants recaptured}}.$$

The accuracy of this formula depends on the assumptions that all ants in the colony are equally susceptible to capture, that the marked ants mix thoroughly with the unmarked, and that the marking is permanent and has no adverse influence on the ants during the length of the sample period.

Chew admitted that, because of the existence of specialized castes, e.g., the repletes of *Myrmecocystus* species, the first as-

sumption is not always permissible, and hence the method is not suitable for certain species. However, he claimed that the exceptions are few and do not limit the application of the method to most North American species of ants. I feel, however, that until much more is known of the foraging behaviour of ants this assumption is not valid for any species, and that the Lincoln Index is of doubtful value in estimating colony size.

The following is an analysis of the use of this method based on laboratory experiments with three species of Formicinae and on the known behaviour patterns of other species of ants.

METHODS

Colonies of *Formica fusca* (Linné), *F. exsectoides* Forel, and *Camponotus herculeanus* (Linné) of known sizes were reared in a laboratory at 23° C. and 50 per cent R.H. Though the structure and design of the nests varied slightly each had an inner partitioned chamber cooled to 12° C. and an outer unpartitioned chamber at room temperature (23° C.). The foraging area of each colony of *F. fusca* and *C. herculeanus* was 2 by 4 feet; that of *F. exsectoides* was 8 by 12 inches. All colonies were fed unlimited amounts of 50 per cent honey solution and house fly larvae.

Approximately 25 per cent of all foraging workers were marked in the colonies of *C. herculeanus*. All foraging workers were marked in colonies of *F. exsectoides*. *F. fusca* had few foraging workers and the samples were obtained by removing all workers that emerged from the nest over a continuous period. The ants were marked on the dorsum of the thorax with a "Tech-pen." Unless otherwise stated, resampling was by counting all the ant in the forage area and not by removing a sample of a given size.

OBSERVATIONS

The number of workers of *F. fusca* in the forage area was extremely low, varying from 0 to 13 at any given time. As only 30 of 3000 workers were marked the figures obtained were very variable and were not considered satisfactory for use in the Lincoln Index formula. Therefore, the totals of nine hourly readings were used and gave estimated populations of 193, 240, 95, 300 and 1080 on the five days following marking.

A spot check on the foraging population of this nest one month

later gave 22 unmarked ants and none marked. A ten-minute count of all ants leaving the nest at this same time gave 71 unmarked and none marked.

The calculated and actual populations of three colonies involving *F. exsectoides* and *C. herculeanus* are shown in Table I. Table IIa shows the total number of marked and unmarked ants present in the foraging area during five days sampling of a colony of 2300 *C. herculeanus* in which 50 workers were marked. Table IIb shows the calculated populations based on the data presented in Table IIa.

TABLE I
COLONY SIZE AS CALCULATED FROM THE LINCOLN INDEX COMPARED
TO THE ACTUAL SIZE

Species	No. of Ants Marked	Inter- val to Resam- pling	Sample		Esti- mated Popula- tion	Actual Popula- tion
			Total No. of Ants	No. of Marked Ants		
<i>Formica</i> <i>exsectoides</i>	25	24 hrs.	50	7	179	1200
		5 days	35	4	219	1200
		6	35	7	125	1200
<i>Formica</i> <i>exsectoides</i>	15	6 days	25	11	34	300
<i>Camponotus</i> <i>herculeanus</i>	40	20 hrs.	76	28	109	3000
		24 hrs.	74	24	123	3000

Immediately after these samples on *C. herculeanus* were taken, the colony was transferred to another nest by dumping it into a new forage area, thus effecting a complete mixing of all workers. Two hours later 36 marked workers were among 259 that remained in the forage area. The population calculated from these figures was 371, which is within the range of calculated populations as shown in Table IIb.

DISCUSSION

Under these experimental conditions about 80 per cent of the ants in colonies of the three species studied do not forage; hence there is some division of labour among the workers. In some ants, particularly those with dimorphic worker castes, division of labour is well known. Extreme modification of the workers limits

TABLE IIa

NUMBER OF MARKED (M) AND UNMARKED (U) ANTS IN THE FORAGE AREA OF
A COLONY OF *CAMPONOTUS HERCULEANUS* THAT CONTAINED
50 MARKED WORKERS

Time	Days from Time of Marking									
	1		2		3		4		5	
	M	U	M	U	M	U	M	U	M	U
9 a.m.	37	162	25	149	26	137	37	151	33	182
10 a.m.	32	197	35	171	30	132	32	172	27	154
11 a.m.	40	153	31	143	33	178	29	163	39	145
12 a.m.	34	147	37	156	32	152	27	157	31	122
1 p.m.	31	136	32	135	37	167	28	177	28	123
2 p.m.	33	185	29	161	41	183	29	124	29	147
3 p.m.	39	131	47	198	29	196	33	113	30	163
4 p.m.	37	142	42	121	26	173	33	136	31	147
5 p.m.	34	123	36	146	no data		35	142	27	152

Average number of workers in forage area = 186.07 ± 3.42

TABLE IIb

POPULATIONS OF A COLONY OF 2300 *CAMPONOTUS HERCULEANUS* AS
CALCULATED BY THE LINCOLN INDEX FROM THE DATA IN TABLE IIa

Time	Days from Time of Marking				
	1	2	3	4	5
9 a.m.	269	348	313	254	326
10 a.m.	358	294	270	319	335
11 a.m.	241	281	320	331	236
12 a.m.	266	261	288	341	247
1 p.m.	269	261	276	366	270
2 p.m.	330	328	273	264	303
3 p.m.	218	261	388	221	322
4 p.m.	242	194	383	256	287
5 p.m.	231	253	no data		331

Average calculated population = 288.14 ± 6.94

them to one or few duties (Wilson, 1953). Division of labour is less clearly marked in species with a monomorphic worker caste. Chen (1937) showed that workers of *Camponotus* of different sizes tend to perform different duties but all were capable of performing the same task. Dobrzanska (1959) obtained similar information for the genus *Formica*. Physiological, rather than size, differences, largely determine the duties of the individual. The Lincoln Index is not a satisfactory means of estimating complete colony size where such physiological differences exist and promote a division of labour within a worker population.

In the individual experiments the number of *F. fusca* in each sample was very low, and thus no attempt was made to analyse the data statistically. The variation in estimated population could have been a reflection of natural variation in the behaviour of individuals. However, the infinite population, as would be calculated from the data one month later, probably resulted from a combination of the loss of marking compound and a change in behaviour of individuals. Some marked workers could still be found but all were in the cooler portions of the nest. (Marking trials with spiders have shown that "Tech-pen" ink will adhere for one year (A. L. Turnbull, personal communication) but its usefulness with these three species of ants was found to be limited to 10 days. The reciprocal cleaning activities of the workers resulted in complete removal of the ink in a period of 2 to 3 months.)

In *F. exsectoides* and *C. herculeanus* essentially the same groups of individuals were engaged in foraging for at least six days. In *C. herculeanus*, not only did the same group of individuals forage, but, under constant temperature and humidity, the number of foragers remained relatively constant. The small variation in these data (Table IIa) suggests that a correction factor might be applied to the samples to give a more accurate estimate of the population. However, a correction factor applied to the extremes in the data gives a 100 per cent difference (1552–3104) in estimated population. Hence, despite the accuracy of a number of samples, one sample would be unreliable. It would not be feasible to take samples every hour in the field as the ants returned from the first sample would not be completely redistributed in the population in time to take the second sample.

Samples from the field can be expected to be more variable than those obtained in the laboratory. Temperature, humidity, and other meteorological factors influence the number of ants foraging. Talbot (1943) showed that within certain temperature ranges the number of foraging workers of *Prenolepis imparis* Say may increase by six times with five degree change in temperature. Changes of similar magnitude were also shown for species of *Formica*, *Lasius*, and *Myrmica* with ten degrees change in temperature (Talbot, 1946). On the other hand Talbot's studies also showed that changes of 5 to 10 degrees within

different temperature ranges had little effect on the number of ants foraging. There would be a different dilution of marked among unmarked workers if samples were taken at a different temperature than that at which the ants were marked.

Steyn (1954) showed that the effects of temperature and humidity caused a seasonal division of labour in colonies of *Anoplolepis custodiens* Smith and that at certain times one caste was excluded from foraging. During the winter only the smaller workers continued to forage; the larger became hibernating fat-repletes. This behaviour pattern would seriously affect the mix-

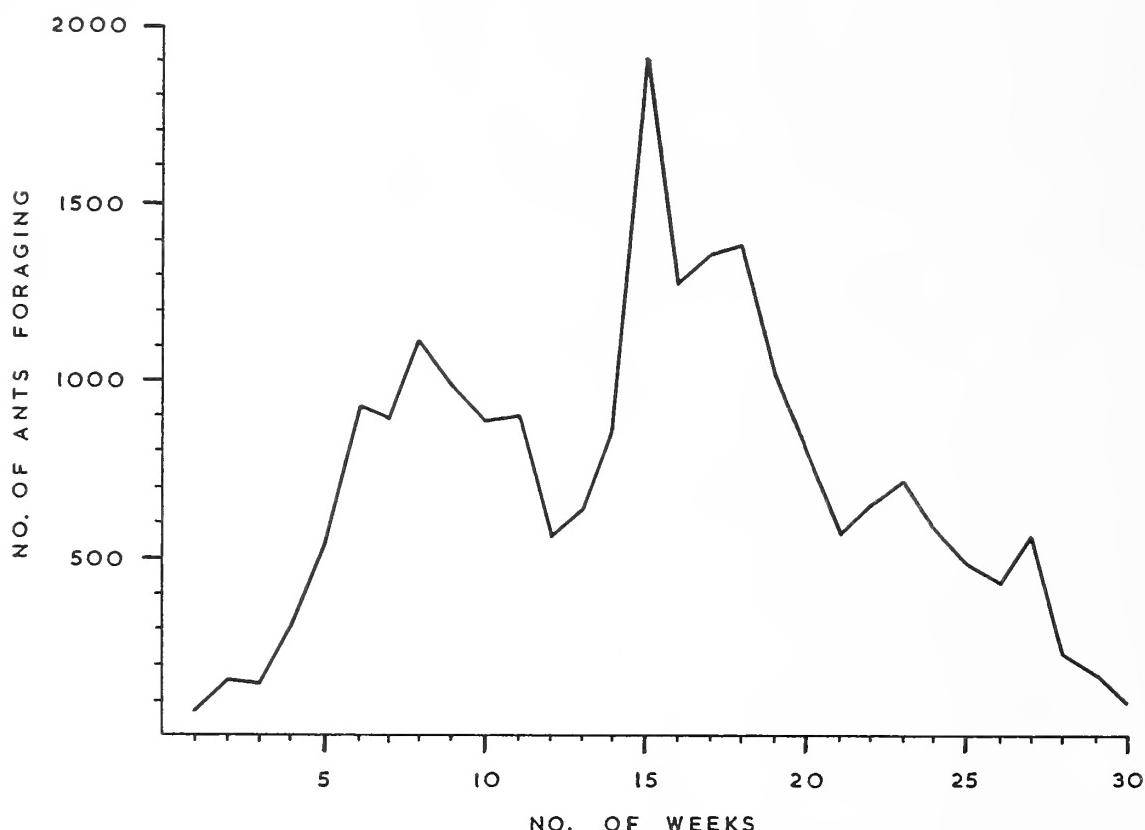


FIG. 1. Numbers of *Formica exsectoides* Forel foraging during a 30 week period.

ing of individuals in the colony and the percentage of the colony foraging would vary with the season.

The state of development of the brood affects the number of ants foraging and therefore the degree of mixing of marked and unmarked ants. The number of *F. exsectoides* leaving a rearing nest during a 10 minute period was recorded at 9 a.m., 1 p.m., and 5 p.m. each day from Monday through Friday for the entire foraging season. Temperature and humidity were constant throughout the entire period. The weekly totals of these data

are shown in Figure I. The peak in activity that occurred eight weeks after establishing the colony represents the period of greatest food consumption by the larvae. The subsequent decline in activity occurred when the larvae pupated. The gradual increase beginning in the 12th week and the sudden increase in the 14th week correspond to the time of worker emergence. As the callow workers do not forage, the variation in the forage population to that time represents variation in the behaviour of individuals in the initial population. The presence of a brood stimulates not only the activity of individuals already foraging but also that total number of ants foraging (Vowles, 1953). This increase may be caused directly by stimuli from the brood or indirectly by stimuli from the more active workers (Chen, 1937).

The location where the foraging workers are sampled can affect calculations for total population. Samples taken at the nest opening or in the immediate vicinity of the nest would contain a high portion of workers that are engaged in constructing, cleaning, or repairing the nest. Samples taken in the general forage area of the nest would contain a high portion of ants that are engaged in foraging for insect food or in gathering honeydew. Dobrzanska (1958) showed that in certain species of *Formica* there is a partitioning of the forage area and that the workers may even confine their activities to single trails for limited periods. Dobrzanska, however, also showed that there is apparently no partitioning of the forage area in certain species of *Lasius*, *Tetramorium*, *Myrmica*, and *Leptothorax*, but she did not indicate if certain ants confine themselves to certain duties. These differences in foraging behaviour further point out the difficulties to be encountered when the Lincoln Index is used as a sampling technique for ants.

CONCLUSION

Some of the problems involved in estimating the size of ant colonies are discussed. Unless one has a considerable knowledge of the foraging behaviour of the ant species concerned the index can give inaccurate or misleading results. However, the index may have an application to ants in comparative studies between colonies, of the same species, in showing variation in foraging activities of the one colony, and, as suggested by Chew, in showing colony growth. It must be kept in mind that data obtained in

this manner is relative and does not necessarily indicate the actual numbers of ants in the colonies.

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The author wishes to thank Miss M. Narusevicius for assistance in sampling the ant colonies used in these experiments.

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THE ECTOPARASITES OF RHODE ISLAND MAMMALS

II. A COLLECTION OF ANOPLURA FROM NON-DOMESTIC HOSTS (ANOPLURA)

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ABSTRACT

A collection of 1042 anoplurans collected on 13 mammalian host species in Rhode Island is reported. Eleven species have been identified: *Enderleinellus longiceps*, *E. marmotae*, *E. nitzschi*, *Hoplopleura acanthopus*, *H. erraticata*, *H. hesperomydis*, *H. sciuricola*, *Neohaematopinus sciuri*, *N. sciuropteri*, *Polyplax alaskensis*, *P. spinulosa*. *Enderleinellus nitzschi* is reported for the first time from the northeastern United States.

Most of the 1042 sucking lice (representing 217 collections) reported here were collected incident to a survey of wild mammals and their parasites conducted during the period 1955 through 1957 as a joint project of the Rhode Island Division of Fish and Game and the University of Rhode Island. Techniques employed were described in some detail in the preceding paper of this series (Hyland and Mathewson, 1961). With few exceptions, all specimens have been deposited in the Entomological Collection of the Department of Zoology at the University of Rhode Island.

The entire louse yield from less commonly collected hosts and from host individuals bearing few lice was mounted and determined. In the case of heavily parasitized individuals of more plentiful types of mammals only part of the yield was determined. Our data are therefore primarily qualitative and indicate relative abundance only.

Attention is called to Scanlon's recent paper on Anoplura and Mallophaga of the nearby New York area (Scanlon, 1960) which contains an extensive bibliography and discussions of synonymy applicable to the forms reported here.

Data for each louse species are presented according to host, locality, number of yielding hosts, and month. The number in parentheses signifies the number of host individuals from which the reported yield was taken. Louse yield is broken down into life-history stages and sex of adults. Mainland localities are reported according to county, while all insular localities are labeled as such except for the Township of Jamestown, which occupies the entirety of Conanicut Island.

Annotations are limited to items of special interest or concern.

While keys to species of nymphs of *Enderleinellus*, *Neohaematomitus*, and *Polyplax* were not available, the fact that these genera were invariably represented by only one species on each of the host forms involved appeared to justify assigning nymphs of those genera in accordance with host association.

We are happy to acknowledge our indebtedness to Mr. John Cronan, Rhode Island Division of Fish and Game, for identification of mammals; to Dr. Harry D. Pratt, Communicable Disease Center (USPHS), Atlanta, Georgia, for verification of determination of representative specimens of each species of louse reported; and to Dr. Richard F. Darsie, Jr., University of Delaware, for the loan of specimens for comparison.

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ANNOTATED LIST

M = male

F = female

N = nymph

ENDERLEINELLUS NITZSHI Fahrenholz

ex *Sciurus carolinensis*

Washington County,	May	(1):	3FF
Kent County,	Jan.	(1):	1F
	Nov.	(1):	1F

All of our specimens represented typical *E. longiceps*. This is in agreement with Scanlon's (1960) findings in New York.

ENDERLEINELLUS MARMOTAE Ferris

ex *Marmota monax*

Washington County,	Apr.	(2):	2FF
	May	(3):	2MM, 2FF, 2NN
	Jul.	(1):	1M, 1F

ENDERLEINELLUS NITZSHI Fahrenholzex *Tamiasciurus hudsonicus*

Washington County, Apr. (1): 3FF

This louse has been reported from western United States and from China, but is apparently not common anywhere. Our specimens are apparently the first reported from northeastern United States. One slide has been deposited in the collection of the Communicable Disease Center (USPHS) in Atlanta, Georgia.

HOPLOPLEURA ACANTHOPUS (Burmeister)ex *Microtus pennsylvanicus*

Washington County,	Mar. (2):	1M, 2FF
	May (9):	29MM, 21FF, 19NN
	Jul. (2):	2MM, 1F
Newport County,	Dec. (9):	33MM, 76FF, 11NN
Bristol County,	Feb. (1):	1M, 2FF, 5NN
Kent County,	Feb. (1):	2FF
Providence County,	Feb. (2):	3FF
Jamestown,	Jan. (1):	1F
	Apr. (2):	3MM, 2FF, 2NN
	Jun. (1):	1F
Prudence Island,	Jun. (8):	6MM, 11FF, 13NN
Patience Island,	Jun. (13):	4MM, 10FF, 15NN

ex *Peromyscus leucopus*

Jamestown,	Apr. (1):	1N
Kent County,	Dec. (1):	1F

ex *Blarina brevicauda*

Kent County,	Apr. (1):	1F
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ex *Myotis lucifugus*

Washington County,	May (1):	1F
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Recovery of specimens from *Peromyscus*, *Blarina*, and *Myotis* is of interest. *H. acanthopush* has previously been reported from *P. leucopus* in Delaware by MacCreary (1945) and in New Jersey by Race (1956). The latter reported (*ibid.*) recovery of a single female from *Blarina*. The occurrence of one female on *Myotis* should probably be viewed as accidental.

HOPLOPLEURA ERRATICA (Osborn)ex *Tamias striatus*

Washington County,	Apr. (2):	2FF, 1N
	Jul. (1):	1M, 3FF
	Aug. (1):	1M, 3N
	Sep. (1):	2FF
	Oct. (2):	1M, 1N

One nymph (#192), found alone on its host, exhibited some apparently anomalous features, but is reported here as typical *H. erratica* pending results of further study.

HOPLOPLEURA HESPEROMYDIS (Osborn)ex *Peromyscus leucopus*

Washington County,	Jan.	(2):	1M, 1F
	Feb.	(2):	1M, 2FF
	Mar.	(3):	4MM, 8FF
	Apr.	(3):	2MM, 2FF
	Jun.	(3):	3FF
	Aug.	(2):	1M, 1F
	Dec.	(4):	4MM, 6FF
Providence County,	Jul.	(10):	11MM, 27FF, 1N
	Aug.	(5):	4MM, 12FF
	Sep.	(2):	3MM, 6FF
Kent County,	Oct.	(1):	1N
	Nov.	(2):	1M, 6FF
	Dec.	(1):	1F
Bristol County,	Feb.	(2):	1M, 2FF
Jamestown,	Apr.	(9):	9MM, 14FF, 2NN
Block Island,	Oct.	(3):	3MM, 18FF
Prudence Island,	Jun.	(2):	2FF

ex *Mus musculus*

Block Island,	Oct.	(1):	1F
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ex *Blarina brevicauda*

Washington County,	Mar.	(2):	4FF
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Ferris (1951) reported recovery of this species from *Mus musculus* from both the Old and New Worlds.

The occurrence on specimens on the Short-tailed Shrew is novel.

A few individuals showed variation in formation of the paratergites of the seventh abdominal segment. In the case of one of these the formation corresponded to that used by Ferris (1951) to erect the species *H. reithrodontomydis*. Discovery of specimens showing intergradations in this character caused Ferris (1953) to sink *reithrodontomydis* as a synonym of *hesperomydis*. Our observations apparently show the same type of variation.

HOPLOPLEURA SCIURICOLA Ferrisex *Sciurus carolinensis*

Washington County,	Jan.	(1):	2MM, 2FF
	Feb.	(1):	1F
	Apr.	(1):	2MM, 1F
	May	(1):	1M, 2FF
	Jun.	(2):	2FF, 2NN
	Nov.	(1):	3FF
	Dec.	(1):	1F
Kent County,	Jan.	(1):	2MM, 3FF, 11NN
	Apr.	(1):	1M, 2FF
	May	(1):	1F

	Aug.	(1):	1M
	Sep.	(2):	2MM, 4FF, 2NN
	Nov.	(2):	5FF, 6NN
Providence County,	Feb.	(1):	1M, 3FF, 4NN

NEOHAEMATOPINUS SCIURI Janckeex *Sciurus carolinensis*

Washington County,	Jan.	(1):	2FF, 2NN
	Feb.	(1):	1F, 2NN
	Mar.	(1):	1N
	Apr.	(3):	1M, 2FF, 6NN
	May	(1):	2MM, 2NN
	Jun.	(5):	1M, 2FF, 7NN
	Jul.	(1):	5MM, 1F, 11NN
	Sep.	(3):	3MM, 3FF, 12NN
	Oct.	(2):	4MM, 11NN
	Nov.	(3):	3FF, 1N
	Dec.	(1):	3NN
Kent County,	Jan.	(1):	4FF, 5NN
	Apr.	(1):	1F
	Aug.	(1):	2MM, 4FF, 5NN
	Sep.	(2):	3MM, 3FF
	Oct.	(1):	3MM, 11FF, 2NN
	Nov.	(9):	3MM, 13FF, 36NN
Providence County,	Feb.	(1):	1M, 2FF
	Jul.	(1):	2MM, 2FF

ex *Ondatra zibethicus*

Providence County,	Aug.	(1):	1M, 1N
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While some variations in the second antennal segment were noted, none of our specimens exhibited structure typical of *N. sciurinus*. Our observations, therefore, support the contention of Johnson (1959) and Scanlon (1960) that the species of *Neohaematopinus* found on *Sciurus carolinensis* in this country is consistently *N. sciuri*.

Biting lice have not previously been found on the Muskrat. Since the likelihood of habitat contamination is small it is possible that the occurrence reported here was accidental.

NEOHAEMATOPINUS SCIUROPTERI (Osborn)ex *Glaucomys volans*

Washington County,	Apr.	(1):	2MM
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POLYPLAX ALASKENSIS (Ewing)ex *Microtus pennsylvanicus*

Washington County,	Jan.	(1):	2MM
	Mar.	(2):	3MM, 6FF, 11NN
	Apr.	(1):	1M, 3FF, 2NN

	May	(9)	:	4MM, 6FF, 7NN
	Jun.	(2)	:	4MM, 6FF, 7NN
	Jul.	(2)	:	2M, 1N
	Oct.	(1)	:	2MM
	Nov.	(1)	:	1F
	Dec.	(1)	:	1M
Newport County,	Dec.	(8)	:	10MM, 12FF, 16NN
Providence County,	Feb.	(1)	:	1F
Bristol County,	Feb.	(1)	:	2FF
Block Island,	Oct.	(6)	:	5MM, 6FF, 28NN
Jamestown,	Jan.	(1)	:	1F
	Apr.	(2)	:	5MM, 7FF, 9NN
	Jun.	(1)	:	1F, 1N
Prudence Island,	Jun.	(1)	:	1F, 1N
Patience Island,	Jun.	(5)	:	2MM, 2FF, 11NN
Dutch Island,	Jun.	(2)	:	2MM, 3FF, 6NN

ex *Peromyscus leucopus*

Washington County, Apr. (1) : 1M, 2FF

P. auricularis is the species of *Polyplax* most often reported from *Peromyscus*. To our present knowledge this is the first *P. alaskensis* from this host.

POLYPLAX SPINULOSA (Burmeister)ex *Rattus norvegicus*

Washington County,	Apr.	(1)	:	1N
	May	(2)	:	2MM, 3FF
	Jun.	(1)	:	2MM, 12FF, 5NN
	Jul.	(1)	:	1F
	Sep.	(1)	:	1F
	Oct.	(1)	:	1M
	Nov.	(3)	:	1M, 4FF, 3NN
	Dec.	(2)	:	2FF, 1N
Providence County,	Feb.	(1)	:	4FF, 3NN
	Jul.	(1)	:	4MM, 5FF
	Aug.	(2)	:	1M, 7FF, 2NN
Newport County,	Dec.	(1)	:	1N
Block Island,	Oct.	(3)	:	2MM, 5FF
Patience Island,	Jun.	(3)	:	4MM, 4FF

ex *Odocoileus virginianus*

Washington County, Jan. (1) : 1M, 1F

These data are in agreement with the findings of Knutson and Szymkowicz (1952) who found this to be the only species of louse on the Norway Rat in Rhode Island. The two individuals found on the White-tailed Deer were probably strays.

HOST-PARASITE LIST

Number in parentheses signifies number of individuals processed

<i>Host</i>	<i>Parasite</i>	<i>No. host individuals infested</i>	<i>Total louse yield</i>
<i>Blarina brevicauda</i> (127)			
	<i>Hoplopleura acanthopus</i>	1	1
	<i>Hoplopleura hesperomydis</i>	2	4
<i>Myotis lucifugus</i> (252)			
	<i>H. acanthopus</i>	1	1
<i>Tamias striatus</i> (25)			
	<i>Hoplopleura erratica</i>	7	15
<i>Marmota monax</i> (114)			
	<i>Enderleinellus marmotae</i>	6	10
<i>Sciurus carolinensis</i> (74)			
	<i>Enderleinellus longiceps</i>	3	5
	<i>Hoplopleura sciuricola</i>	17	67
	<i>Neohaematopinus sciuri</i>	37	190
<i>Tamiasciurus hudsonicus</i> (19)			
	<i>Enderleinellus nitzschi</i>	1	3
<i>Glaucomys volans</i> (2)			
	<i>Neohaematopinus sciuropteri</i>	1	2
<i>Peromyscus leucopus</i> (285)			
	<i>H. acanthopus</i>	2	2
	<i>H. hesperomydis</i>	56	160
	<i>Polyplax alaskensis</i>	1	3
<i>Microtus pennsylvanicus</i> (210)			
	<i>H. acanthopus</i>	51	276
	<i>P. alaskensis</i>	48	217
<i>Ondatra zibethicus</i> (50)			
	<i>N. sciuri</i>	1	2
<i>Rattus norvegicus</i> (76)			
	<i>Polyplax spinulosa</i>	23	81
<i>Mus musculus</i> (27)			
	<i>H. hesperomydis</i>	1	1
<i>Odocoileus virginianus</i> (17)			
	<i>Polyplax spinulosa</i>	1	2
Number species Mammal	13		
Number species Anoplura	11		
Total host individuals yielding one or more species of Anoplura	217		
Total Anoplura determined and reported	1042		

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- SCANLON, J. E. 1960. The Anoplura and Mallophaga of the mammals of New York. *Wildl. Dis.* No. 5, May 1960, 121 pp. on 3 cards, illus.
- TINDALL, E. E. AND R. F. DARSIE, JR. 1961. New Delaware records for mammalian ectoparasites, including Siphonaptera host list. *Bull. Brooklyn Entomol. Soc.* **56**(4): 89-99.

BOOK REVIEW

MONOGRAPHIE DER OSTASIATISCHEN FORMEN DER GATTUNG *MELANARGIA* MEIGEN (LEPIDOPTERA: SATYRIDAE). Sigbert Wagener. Zoologica, 39 Band, Heft 108: 56 plates, 26 text illustrations, 13 tables, 8 maps. Lieferung 1, 1959; Lieferung 2, 1959; Lieferung 3, 1961. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

This exceedingly important work will long stand as a landmark, not only in the systematics of the widespread genus of Palaearctic butterflies which it partially covers, but in the general study, and especially the Zoogeography, of Palaearctic insects and other animals. The number of species recognized from the region is reduced to 8, scores of other names being used as applying to forms or subspecies of these. A total of 3413 specimens of both sexes were studied in all the prominent European museums. Their variations are listed in tables which will make possible statistical analyses by other methods. A large number of male genitalia dissections were made, and the variations of these figured. Many new subspecies are named. Other important data are given including the synonymy and the bibliographic references for all generic, specific and infraspecific, names, and the location and data of all known type material. The thorough bibliography includes references to many pertinent papers in systematics and morphology. The maps of East Asia and the synonymic lists of collecting localities there (a very troublesome matter) will be of great service to other workers. Especially valuable is the lengthy discussion of the postulated evolution as evidenced by subspeciation and affected by the climatic factors, the isolation of populations and the geologic history of the region. The author is to be congratulated on an accomplishment that will prove of great value to workers in many fields.

ALEXANDER B. KLOTS
RESEARCH ASSOCIATE
DEPARTMENT OF ENTOMOLOGY
AMERICAN MUSEUM OF NATURAL HISTORY

NEW BOOKS

Termites—Their Recognition and Control, W. Victor Harris. Published by Longmans, England, 1961, 187 pages, photographs and line drawings. Price in Great Britain 40/- net. Mr. Harris discusses the natural history, means of identification and geographical distribution of termites. An appendix gives additional details of chemicals used in termite control.

The Story of Ants, S. H. Skaife. Published by Longmans, England, 1961, 178 pages, illustrated with 69 line drawings and 2 photographs. Price in Great Britain 25/- net.

Written by the President of the Entomological Society of Cape Town, Africa for the layman this book tells how to capture, keep and proceed to study ants.

Medical Entomology: Arthropods and Human Disease, William R. Horsfall. Published by the Ronald Press, 1962, 425 pages, illustrated. Price \$10.00. The arthropods and diseases discussed include examples taken from all continents. The book uses detailed descriptions of type situations and information on finding appropriate keys of local interest. An appendix showing keys to medically important arthropods by category and area is a unique feature of this book.

Bee Venom, The Natural Curative for Arthritis and Rheumatism, Joseph Boardman, M.D. Dr. Boardman, a medical practitioner, tells how he has used bee venom to treat arthritic and rheumatic patients. Included are reports from European clinics and research centers.

The World of Ants, G. Collins Wheat. Published by Golden Press, Revised edition 1961, 54 pages, illustrated in color and black and white. Price \$.69. This is another in the Golden Library of Knowledge series and tells how the ants live, work and communicate within their colonies.

The Story of Pollination, J. D. Meeuse. Published by The Ronald Press, 1962, profusely illustrated.

It describes the self-pollinating flowers and those that rely on wind and water, and traces the pollinating activities of bees and bumblebees, wasps, butterflies, hawkmoths, flies, beetles, birds and bats.

AN ANNOTATED LIST OF THE LYCAENIDAE (LEPIDOPTERA, RHOPALOCERA) OF THE WESTERN HEMISPHERE

BY WILLIAM PHILLIPS COMSTOCK AND EDGAR IRVING HUNTINGTON

[CONTINUED]

porphyritis Druce, Hamilton H., *Thecla*

Type Locality: Tapajos and Pará, Brazil.

Location of Type: Godman Collection (British Museum).

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 595, pl. 35, fig. 4 ♂ (London).

porsenna Scudder, Samuel H., *Polyommatus*

Type Locality: New England.

Location of Type:

Original Description: 1864, Proc. Essex Inst., vol. 3, p. 163 (Salem, Mass.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 25, no. 419 (Los Angeles, Calif.). (Places *porsenna* as a synonym of *tarnquinius* Fabricius.)

porthura Druce, Hamilton, H., *Thecla*

Type Locality: Bogotá, Colombia.

Location of Type: Godman Collection (British Museum).

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 581, pl. 33, fig. 10 ♂ (London).

portoena Clench, Harry K., *Thecla*

Type Locality: Cussiluni, Bolivia, May, 1899.

Location of Type: Museum of Comparative Zoology, no. 26, 227.

Original Description: 1944 (July), Bull. Mus. Comp. Zool., vol. 94, p. 242 (Cambridge, Mass.).

Additional Reference: Weeks, A. G., 1905, Illus. of Diurnal Lepidoptera, vol. 1, p. 19 (Boston, Mass.). (Lists *Thecla deidamia* Burmeister (not Ruschheweyh). These specimens are the types of *portoena*.

posetta Dyar, Harrison G., *Thecla*

Type Locality: Porto Bello, Panama.

Location of Type: United States National Museum, no. 15,759.

Original Description: 1915, Proc. U. S. Natl. Mus., vol. 47, p. 150 (Washington, D. C.).

Additional Reference: Schaus, William, 1920, Ent. News, vol. 31, p. 176 (Philadelphia, Pa.). (Makes *posetta* a synonym of *amphrade* Schaus.)

praxis Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Panamá and Colombia.

Location of Type: British Museum (Natural History).

Original Description: 1887 (August), *Biologia Centrali-Americana*, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 52, vol. 3, pl. 54, figs. 12, 13 ♂ (London).

primno Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Chiriquí, Panamá.

Location of Type: Staudinger Collection.

Original Description: 1887 (June), *Biologia Centrali-Americana*, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 47, vol. 3, pl. 53, figs. 25, 26 ♀ (London).

Additional References: Druce, H. H., 1907 (June), *Proc. Zool. Soc. London*, p. 587 (London). (Considers *primno* a synonym of *elsa* Hewitson.) Draudt, Max, 1920 (January), *The Macrolepidoptera of the World*, vol. 5, p. 771 (Stuttgart). (Makes *primno* a synonym of *elsa* Hewitson.)

primnoza Dyar, Harrison G., *Thecla*

Type Locality: Misantla, June, 1911; Santa Rosa, V. C., May 1906, Mexico.

Location of Type: United States National Museum, no. 14,277.

Original Description: 1912, *Proc. U. S. Natl. Mus.*, vol. 42, p. 41 (Washington, D. C.).

Additional References: Schaus, William, 1920, *Ent. News*, vol. 31, p. 176 (Philadelphia, Pa.). (Makes *primnoza* Dyar a synonym of *elsa* Hewitson.) Draudt, Max, 1921 (January), *The Macrolepidoptera of the World*, vol. 5, p. 771 and p. 823 (Stuttgart). (Makes *primnoza* (♂) a synonym of *elsa* Hewitson.)

proba, Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Calobre, Panamá.

Location of Type: British Museum (Natural History).

Original Description: 1887 (August), *Biologia Centrali-Americana*, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 64, vol. 3, pl. 56, figs. 1, 2 ♂, 3 ♀ (London).

Synonyms: *climicles* Dyar.

promissa Möschler, H. B., *Thecla*

Type Locality: Paramaribo, Surinam.

Location of Type:

Original Description: 1883, *Verh. Zool.-bot Ges.*, vol. 32, p. 311, pl. 17, fig. 9 (Wien).

Additional Reference: Schaus, William, 1920, *Ent. News*, vol. 31, p. 176, (Philadelphia, Pa.). (Makes *promissa* a synonym of *sabinus* Felder.)

provo Watson, Frank E. and W. P. Comstock, *Strymon saepium*

Type Locality: Provo, Utah, July 9, 1909 (Collector T. Spalding).

Location of Type: American Museum of Natural History.

Original Description: 1920 (December), Bull. Amer. Mus. Nat. Hist., vol. 42, art. 10, p. 452 (New York, N. Y.).

pruina Scudder, Samuel H., *Thecla liparops* ab.

Type Locality: Walpole, Massachusetts, July 20.

Location of Type:

Original Description: 1889, The Butterflies of the eastern United States and Canada with special reference to New England, vol. 2, p. 879 (Cambridge, Mass.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 24, no. 389 (Los Angeles, Calif.). (Places *pruina* as an aberration of *strigosa* Harris.)

pseudaon Capronnier, J. B. *Thecla Nomen nudum*

Type Locality: Botafogo, Brazil.

Location of Type:

Original Description: 1874, Ann. Soc. Ent. Belgique, vol. 17, p. 15 (Bruxelles).

pseudarcula Giacomelli, Eugenio, *Thecla*

Type Locality: La Rioja, Argentina.

Location of Type: Giacomelli Collection?

Original Description: 1914, An. Soc. Cient. Argentina, vol. 78, p. 164 (Buenos Aires).

Synonyms: *pseudarenaia* (Zool. Record).

pseudarenaia, *Thecla* Misspelling of *pseudarcula* Giacomelli

Type Locality:

Location of Type:

Original Description: 1929, Zool. Record, vol. 65, Insecta, p. 241 (London).

pseudargiolus Boisduval, Jean. A. and John LeConte, *Argus*

Type Locality: United States.

Location of Type:

Original Description: 1833, Histoire Générale et iconographie des Lépidoptères et des chenilles de l'Amérique Septentrionale, p. 118, pl. 36, figs. 1-5 (Paris).

Additional Reference: Oberthür, Charles, 1920, Etudes de Lepidoptérologie Comparee, fasc. 17, p. 20, pls. 7, pl. p. DV, figs. 4211, 4212 (Rennes).

Synonyms: *neglecta* Edwards, *deutargiolus* Scudder syn. *neglecta-major* Tutt, *obsoleta-lunulata* Tutt, *pseudora* Scudder, *subtus juncta* Tutt, *violacea* Edwards, *argiolus* Abbot and Smith, *brunnea* Tutt, *fumida* Scudder, *inaequalis* Tutt, *lucia* Kirby, *intermedia* Strecker syn., *nigra* Strecker syn., *nigra* Edwards syn., *marginata* Edwards.

Subspecies: *nigrescens* Fletcher, *quesnelli* Cockle syn., *maculata-suffusa* Cockle syn., *sidara* Clench, *argentata* Fletcher, *bakeri* Clench, *cinerea* Edwards, *arizonensis* Edwards syn., *echo* Edwards, *nunenmacheri* Strand syn., *gozora* Boisduval.

PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF OCTOBER 6, 1959

Minutes not available for this meeting.

MEETING OF OCTOBER 20, 1959

President Shoumatoff called the meeting to order at 8:05 P.M. in Room 129 of the American Museum of Natural History. The 15 members and two guests present were welcomed by him. The minutes of the previous meeting were approved as read. Under miscellaneous business the President commented upon the two New York State constitutional amendments which are to be voted upon on Election Day. Dr. Lucy Clausen, our delegate to the N. Y. Academy of Sciences, reported that for some time now our Society, and similar ones affiliated with the Academy, carry no weight in the discussions at their business meetings. Mr. Frank Soraci, the Editor, stated that the last two parts of the current volume would be combined into a single issue and this will bring the JOURNAL up to date. Mr. Lucien Pohl noted that the albatross is in danger of becoming extinct because of the great number of collisions with airplanes. President Shoumatoff mentioned that an adult member must be present at all Junior Society meetings. He also announced that the new book by Dr. and Mrs. Alexander Klots **Living Insects of the World**, is now available.

The program of the evening, devoted to the members' summer activities, was started by Robert Bloch who showed a sweater knitted by his wife which had an insect design; the insects were all made in proportion to their actual sizes. Three members had made foreign tours; Peter Dix and Lucien Pohl to Europe and Mrs. P. Vaurie to Mexico. These were reported by descriptions and some colored slides. Lucy Clausen had some ichneumonids under observation; J. Huberman, commenting on insect control within the city, stated that the organic phosphates were still doing a better job than the newer insecticides; E. W. Teale enjoyed his new home and insect garden in Hampton, Conn.; N. Shoumatoff toured the west as did the Klotses and brief descriptions of these trips were illustrated with a few colored slides. B. Heineman spent some time in the 1000 Islands and reported that the Monarch butterfly was scarce this year. However, his light trap collections were rewarding and much of this material he turned over to the Museum. R. Brush stated that some of the moths he collected this summer at Candlewood Lake in Conn. had been donated to the Museum. Miss White visited some of the western national parks and was enthusiastic about the assistance rendered by the rangers.

The President reminded the members that the first Tuesday in November is Election Day and, thus, there will be no meeting. The meeting adjourned at 10:15 P.M.

ROBERT G. BLOCH, *Secretary*

MEETING OF NOVEMBER 17, 1959

At 8:15 P.M. the President called the meeting to order in Room 129 of the American Museum of Natural History and welcomed the 14 members and eight guests present. The reading of the minutes of the previous meeting was postponed because of the absence of our Secretary. Mr. Soraci, the Editor, announced that the last part of the 1959 volume is in the hands of the printer and that this will be distributed in December; making it current. Mrs. Lilli Mautner was proposed for membership by Mr. Brush. Mr. Shoumatoff appointed a Nominating Committee consisting of Doctors Klots, Treat, and Forbes. A vote of thanks was extended to Dr. Clausen and to Mr. Heineman who are retiring from this committee. Mrs. P. Vaurie sponsored the last two meetings of the Junior Society and reported on their activities. Mr. P. Dix offered to sponsor their next meeting.

Mr. Heineman then introduced the guest speaker, Mr. Eugene Eisenmann, whose subject was, "Carl Linnaeus—Founder of Scientific Classification." Mr. Eisenmann, an amateur naturalist, has done considerable research on Linnaeus. He gave interesting details of the life, the works, and the philosophy of Linnaeus. He traced the history of the *SYSTEMA NATURAE* through the 10th Edition. Using this reference, he keyed out a butterfly which was recognized by many present at *Papilio glaucus*. After a discussion period, the speaker was thanked for his fascinating discourse in which "he seemed to make the great man live for us."

The meeting adjourned at 10:00 P.M.

RAYMOND BRUSH, *Assist. Secretary*

MEETING OF DECEMBER 1, 1959

President Shoumatoff called the meeting to order at 8:05 P.M. in Room 129 of the American Museum of Natural History. There were 25 members and 25 guests present; several of the guests were introduced by members. The minutes of the October 20th and November 17th meetings were read and approved. Mrs. Lilli Mautner was elected a member. Mr. Peter Dix said he will again sponsor the Junior Society's next meeting; he reported 15 were present at their last meeting.

Dr. Treat introduced the speaker of the evening, Dr. A. B. Klots and referred to him as the "Prince of Lepidopterists." He stated that what Audubon did for the birds, Klots is doing for the Lepidoptera; except that he is probably exceeding Audubon's works. Dr. Klots' talk entitled "Western Lepidoptera" was illustrated with many of his beautiful colored slides taken in the area chiefly around the Southwestern Research Station at Portal, Arizona. These included striking pictures of larval, pupal, and adult Lepidoptera.

The meeting adjourned at 10:05 P.M.

ROBERT G. BLOCH, *Secretary*

MEETING OF DECEMBER 15, 1959

The President called the meeting to order at 8:10 P.M. in Room 129 of the American Museum of Natural History; the 15 members and five guests

present were greeted by him. The minutes of the previous meeting were approved as read.

The speaker of the evening, Dr. Kurt Gohla, Professor of German at Fordham University, was introduced by Dr. J. Forbes. Dr. Gohla is an avid, amateur lepidopterist and naturalist. His talk entitled, "The Trail of *Parnassius apollo* in German Literature and in Reality" considered first the writings of Gerhart Hauptmann and Friedrich Schnack dealing with Lepidoptera and with the butterfly *Parnassius apollo* in particular. In the second part of his talk Dr. Gohla told of his trip during the summer of 1958 to the resort town of Berchtesgaden in the Bavarian Alps and his experiences there in successfully obtaining some specimens of this butterfly which he had so long hoped to collect in the field. This is a relict, arctic species which has remained stranded in limestone outcroppings in the mountains as the ice sheets receded northward after the last ice-age.

The meeting adjourned at 9:50 P.M. after an interesting discussion period.

ROBERT G. BLOCH, *Secretary*

MEETING OF JANUARY 5, 1960

President Shoumatoff called the Annual Meeting to order at 8:10 P.M. in Room 129 of the American Museum of Natural History; 20 members and six guests were present. The minutes of the previous meeting were accepted as read. Reports of various committee chairmen were made; Dr. Klots for the Field Committee, Mr. Heineman for the Program Committee. The Treasurer was absent due to illness in his family and will give his report at a later meeting. Mr. Shoumatoff relinquished the chair to Dr. Forbes to have him receive the report of the Nominating Committee. The list of officers for 1960 was presented as follows:

President—Mr. Nicholas Shoumatoff

Vice-president—Mr. Bernard Heineman

Secretary—Mr. Raymond Brush

Assistant Secretary—Mr. Robert Bloch

Treasurer—Mr. Jacob Huberman

Assistant Treasurer—Mrs. Patricia Vaurie

Editor—Dr. William Creighton

Trustees—Mr. Herbert Schwarz, Mr. E. Irving Huntington, Dr. John Schmitt, Dr. A. B. Klots

Delegate, N. Y. Academy of Sciences—Dr. Lucy Clausen

There were no further nominations and the nominees as presented were elected.

Mr. Shoumatoff resumed the chairmanship of the meeting. He thanked the various officers, committees, and members for their support. He pointed out that the retiring Editor, Mr. Frank Soraci, had worked long and hard to bring the JOURNAL up to date and he was pleased to present him with a handsomely executed, parchment testimonial with the following inscription:

THE NEW YORK ENTOMOLOGICAL SOCIETY AT ITS ANNUAL
MEETING JANUARY 5, 1960 PRESENTS TO FRANK A. SORACI
THIS EXPRESSION OF APPRECIATION FOR HIS DEVOTED
AND DISTINGUISHED SERVICE TO THE SOCIETY AS EDITOR,
1950-1959

Mr. Soraci accepted this to a rising vote of thanks. Mr. Shoumatoff reluctantly announced that new higher subscription rates for the JOURNAL would have to go into effect this coming year. The non-member subscription to be \$8.00 per year, member subscription to be \$5.00, and student membership subscription to be \$3.00 per year. The dues remain the same, \$4.00 for full and \$2.00 for student members. It was announced that Dr. Roman Vishniac had been elected a Fellow of the New York Academy of Sciences. Excerpts from the Book Review Column of THE NEW YORK TIMES was read complimenting the recent works of our fellow-member, Edwin Way Teale.

Mr. Shoumatoff gave the talk of the evening entitled, "Butterflies of Jamaica, British West Indies", illustrated with both slides and motion pictures. This was an account of an interesting field trip he took with his uncle, Dr. Andrei Avinoff, the renowned lepidopterist. We learned of the rare species caught and studied, heard some of the quaint Jamaican names and customs, and journeyed through beautiful mountains and valleys.

The meeting adjourned at 10:10 P.M.

RAYMOND BRUSH, *Secretary*

MEETING OF JANUARY 19, 1960

The meeting was called to order by Mr. Shoumatoff at 8:05 P.M. in Room 419 of the American Museum of Natural History; 17 members and 16 guests were present. The minutes of the Annual Meeting were accepted as read. Mr. Huberman, the Treasurer, in his belated report stated that there are 116 members, 204 subscriptions to the JOURNAL, and the bank balance as of December 31, 1959 is \$4337.62. Mr. Mark Indenbaum was elected to membership and the following persons were proposed for membership: Mrs. Harriet Brush, Mr. Roy Vonder Heyden, Mr. Louis J. Simon. A motion to suspend the By-Laws to permit the immediate voting on these proposals was carried and three new members were welcomed into the Society. Mr. Shoumatoff referred to a letter which he had had mimeographed concerning a drive for new members. These letters will be mailed to teachers, students, and institutions likely to be interested in our Society.

Mr. Bernard Heineman introduced the speakers of the evening, Mr. and Mrs. Phillip Bergh. He said that although not entomologists nor scientists, they are an extraordinary couple with a great interest in natural history. Mr. Bergh is employed by the U. S. Rubber Corp. and Mrs. Bergh, presently a housewife, was a teacher at Skidmore College and Pratt Institute. Their talk, "Play of Time on Form and Color", was illustrated with expertly made pictures all taken in and around their home at Little Neck, Queens, N.Y.C.. These highlighted the life history of the Polyphemus moth, the Black Swal-

lowtail butterfly, the Cecropia moth, the Leopard moth, the silk-worm, horned worms, cicadas, and other insects in various stages of their development. After their talk the discussion centered on photographic techniques and technical phases of the pictures.

The meeting adjourned at 10:10 P.M.

RAYMOND BRUSH, *Secretary*

MEETING OF FEBRUARY 2, 1960

In the absence of the President, the meeting was called to order by Mr. Heineman, the Vice-president, at 8:10 P.M. in Room 129 of the American Museum of Natural History; 14 members and eight guests were present. The minutes of the previous meeting were accepted as corrected. Some of the visitors were introduced by members; Mr. Teres of the Brooklyn Entomological Society; Mr. Goray, Mr. LaMell, and Mr. Borg who are students at Rutgers University; Mr. Brassel of Fordham College; and Mr. Schweitzer of Columbia College.

Dr. William S. Creighton, the speaker of the evening, was introduced by Dr. A. B. Klots. He referred to their many years of association, told of Dr. Creighton's varied experiences in the taxonomy, the ecology, and the behavior of ants, and of the assistance Mrs. Creighton gives in this extensive fieldwork. Dr. Creighton discussed "Behavior of *Pheidole militicida* in the Winter Months." This study was made at the Southwestern Research Station, Portal, Arizona. He told of his early difficulties in obtaining specimens of this ant. After trying all kinds of natural bait, Mrs. Creighton made the startling discovery that this species is most fond of French toast. He described their harvesting and storing habits, and their relationships to other species. His observations show that during the winter the major workers are not killed and, though taking no part in crushing the seeds of the foraging minors, they serve as guards. A lively and informative discussion followed the talk.

The meeting adjourned at 9:45 P.M.

RAYMOND BRUSH, *Secretary*

MEETING OF FEBRUARY 16, 1960

President Shoumatoff called the meeting to order in Room 129 of the American Museum of Natural History at 8:05 P.M.; 20 members and six guests were present. The minutes of the previous meeting were accepted as read. Doctors Treat and Klots were designated the official Society delegates to the 11th International Congress of Entomology to be held in Vienna, Austria this summer. Mr. Manlio A. Manzelli of Rutgers University was proposed for membership by Dr. J. Schmitt. Dr. Vishniac mentioned an article in THE NEW YORK TIMES regarding a termite problem in Venice, Italy. One of our guests, Mr. Schweitzer, then referred to an article he had noticed concerning termites in the Kremlin. Mr. Huberman, the Treasurer, announced he had just been notified of the death of two of our members although they had passed away some time ago. They were Dr. Charles L. Fluke, Jr. of the Department of Entomology, University of Wisconsin and Norman S. Easton of Fall River, Mass.

Mr. Shoumatoff introduced the speaker of the evening, Dr. John B. Schmitt, a Trustee of the Society and Professor of Entomology at Rutgers University. His talk entitled, "Studies in the Comparative Anatomy of the Insect Nervous System", was most interesting. During the discussion period Dr. Schmitt described some of his techniques in this research. (An abstract follows.) Dr. Treat was to have been a second speaker, but the projector broke-down and it was decided to postpone his talk until a future meeting.

The meeting adjourned at 9:50 P.M.

RAYMOND BRUSH, *Secretary*

STUDIES IN THE COMPARATIVE ANATOMY OF THE INSECT NERVOUS SYSTEM

Abstract

Homologies of insect segmental musculature have long been recognized, but no corresponding patterns of nerves have as yet been identified. Apart from the mechanical difficulty of tracing insect nerves to their muscle or integumentary terminals, efforts to recognize such patterns have been hampered by the problem of finding suitable criteria of nerve homologies.

As a first step in finding such criteria, the writer made a study of the nerve patterns in the pregenital segments of the abdomen in four families of Orthoptera. Assuming that the nerves of the dorsal longitudinal muscles, the ventral longitudinal muscles and the occlusor and the dilator of the spiracles are respectively homologous in each of these families, a segmental nerve pattern for the pregenital abdominal segments of the Orthoptera was deduced. The essential features of the pattern are these:

1. A "dorsal nerve" serving the dorsal longitudinal muscles and certain ventral and lateral muscles of the segment.
2. A "ventral nerve" serving certain other ventral and lateral muscles of the segment.
3. A branch of the dorsal nerve which connects with the transverse nerve of the unpaired or median nerve (the so-called ventral sympathetic system) thus forming a "loop".
4. A branch of this "loop" providing innervation of the spiracle muscles.
5. In addition in certain families such as Acrididae, Gryllidae and Blattidae, the "ventral nerve" is connected posteriorly to the "loop", thus forming a second loop.
6. In the Acrididae, a pair of very fine nerves lies parallel with the nerve cord and provides innervation to the ventral diaphragm. These nerves, called the "paramedian" nerves, are connected to both the transverse nerves and the dorsal nerves in each pregenital segment.

Comparison of these findings with the corresponding segmental nerves in *Chauliodes* (Megaloptera), as described by Maki (1936) shows complete similarity in all items named above excepting item 5.

Libby (1959) made a similar study of the nerves and muscles of the second and third abdominal segments of the Cecropia larva. He found, despite the great proliferation of muscles in the caterpillar, a nerve pattern resembling

closely that of the cricket. He was thus able to apply the Orthopteroid pattern described above, to the nerves of the abdomen of the caterpillar.

Studies on the nerve pattern in the abdomen of the Plecoptera, not yet published, have revealed the general outlines of this same fundamental pattern. However, the ventral nerve is very weak in *Pteronarcys* or even absent in some segments, and there is a positional anomaly of the transverse nerves of segments 4, 5, 6 and 7 for which the writer has not yet found an explanation.

JOHN B. SCHMITT

ABOUT OUR MEMBERS

Dr. James Forbes of the Fordham University Biological Laboratory has been awarded a National Science Foundation Grant for two years. His research will be a continuation of his studies on the anatomy and histology of male ants.

President John B. Schmitt, Professor of Entomology of Rutgers University is one of the authorities who has contributed to the Annual Review of Entomology, Volume 7, 1962. Dr. Schmitt's article of 20 pages reviews the highly specialized field of "The Comparative Anatomy of the Insect Nervous System."

Two of our members, both of Fordham University Biological Laboratories, were stricken with heart attacks this past academic year. At the end of last October **Dr. James Mullen**, formerly a Vice-President and member of the Publication Committee, was hospitalized. He was able to resume his duties at the beginning of the second semester. On March 18th, **Dr. Daniel Ludwig**, our Vice-President and Program Chairman was taken ill. The original diagnosis was influenza, followed by pneumonia. Later the illness was determined to have been accompanied by a heart attack. His "progress report" indicates a return to normal schedule in the fall.

**JOURNAL
of the
NEW YORK ENTOMOLOGICAL SOCIETY**

The JOURNAL of the NEW YORK ENTOMOLOGICAL SOCIETY is devoted to the advancement and dissemination of knowledge pertaining to insects and their related forms.

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Devoted to Entomology in General



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HERBERT FERLANDO SCHWARZ

Sem dúvida alguma, para o grupo sulamericano estudioso dos meliponídeos, Herbert Schwarz foi o melhor dos embaixadores norteamericanos. Minha primeira correspondência com ele data de janeiro de 1948 quando eu estava preparando minha tese de doutoramento, tese que versava sobre o gênero *Melipona*. Essa correspondência me foi de excepcional valia, primeiro pelo estímulo e sugestões recebidas e, segundo, porque na época, 1945–1948, era difícil encontrar-se no Brasil uma pessoa, no campo dos meliponídeos, que pudesse dar alguma orientação num programa de doutoramento. O que foi para Schwarz o livro “Field Book of Insects” em matéria de inspiração e estímulo foram para mim, posso dizer, os livros de Schwarz “The Genus *Melipona*” e o de Ihering “Da vida dos nossos animais”.

Em fins de 1951, pela primeira vez, apresentei-me diretamente ao Sr. Herbert Schwarz, na cidade de Nova York. Como grande embaixador da boa vontade e querendo deixar num sulamericano a melhor das impressões, além de me mostrar detalhadamente a coleção de Hymenoptera do American Museum of Natural History, levou-me a jantar no Harvard Club.

Por ocasião do Natal, como todos os pesquisadores sulamericanos em meliponídeos, eu recebia seus cuidadosos e delicados cartões de Natal, que mantinham assim uma constante corrente de simpatia.

Paulo Nogueira Neto em uma recente correspondência sobre Mr. Schwarz escreveu o seguinte:

“Since 1946, and until his death, I exchanged hundreds of letters with Mr. Schwarz. He also identified many meliponins for me. In 1959 I had the pleasure of meeting him personally in New York. He was always friendly, detailed in his answers, kind, and willing to help. If I had to sum up his many personal attributes, I would say—in few words—that he was a true gentleman scientist.”

Assim, foi uma rasão de luto e consternação para os amigos sulamericanos saber de sua morte a 2 de outubro de 1960 porque se compreendeu que a ciência perdia um grande elemento. Todavia, maior perda sofreu a causa da amizade entre os povos que em Herbert F. Schwarz teve um de seus grandes lutadores.

Warwick Estêvão Kerr

STING GLANDS IN STINGLESS BEES—A VESTIGIAL CHARACTER (HYMENOPTERA: APIDAE)¹

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FACULDADE DE FILOSOFIA, CIÊNCIAS E LETRAS DE RIO CLARO
RIO CLARO, S.P., BRAZIL

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ABSTRACT

The problem of what has occurred to the sting accessories of the stingless bees is considered. Primitive Meliponini retain the sac homologous to the sac of the acid gland of stinging bees; evolved stingless bees do not have this sac in the workers but do have it in the queens. Since *Apis mellifera* lose their stings as a result of use of the sting in defense, the authors suggest that new methods of defense evolved which do not exact a heavy toll of the colony. The fact that there are at least thirteen ways in which stingless bees protect themselves, makes stings obsolete. In 24 species of Apinae it has been possible to correlate different levels of evolution with: nests, communication systems, mandibular glands and cytology. A diagrammatic representation of evolutionary levels reached by each species is presented.

Social Apidae belong to three different tribes, namely, Bombycini, Apini and Meliponini. This last group is known as stingless bees because the workers have no sting. It has conservatively, 5 genera (*Melipona*, *Trigona*, *Lestrimelitta*, *Dactylurina*, *Meliponula*). Sting accessories (sting acid gland, poison sac and basic gland) of *Apis mellifera* L. have been known since 1841 (Bordas 1895 and Snodgrass 1956). The problem we want to solve is: what has happened with the sting accessories in the stingless bees since they no longer possess a sting. The only stingless bee with a poison gland is *Trigona (Oxytrigona) tataira* F. Smith the poison glands of which are located in the base of the mandibles (Kerr and Cruz 1961) and not in the abdomen.

MATERIAL AND METHODS

We used the following species of bees: *Meliponula bocandei* (Spinola) from Luanda, Angola, Africa: *Dactylurina staudin-*

¹ This research was financed in part by Rockefeller Foundation (grant RF. 60108), and by a grant from United States Department of Agriculture, Agricultural Research Service, under Public Law 480 (FG-Br-102).

geri (Gribodo)², collected in Morogoro, Tanganyika, during the trip of senior author to Africa in 1956; *Apis florea* Fabricius and *Apis dorsata* Fabricius, sent from Ceylon to Kansas and from Kansas to Rio Claro through kindness of Dr. Domiciano Dias; *Melipona* (*Melipona*) *rufiventris* Lepeletier and *Trigona* (*Frieseomelitta*) *freiremaiai* Moure, collected in Guarapari, E.S., Brazil; *Melipona* (*Micheneria*) *marginata* Lepeletier, *Melipona* (*Melipona*) *quadrifasciata* Lepeletier, *Trigona* (*Tetragonisca*) *jaty* F. Smith, *Trigona* (*Plebeia*) *droryana* Friese, *Trigona* (*Plebeia*) *schottkyi* Friese, *Trigona* (*Nannotrigona*) *testaceicornis* (Lepeletier), *Trigona* (*Partamona*) *cupira* F. Smith, *Trigona* (*Trigona*) *amalthea* (Olivier) (= *Trigona trinidadensis*), *Trigona* (*Trigona*) *hyalinata* (Lepeletier), *Trigona* (*Trigona*) *spinipes* (Fabricius) (= *Trigona ruficrus*), *Trigona* (*Scaptotrigona*) *postica* (Latreille), *Trigona* (*Scaptotrigona*) *bipunctata* (Lepeletier), *Trigona* (*Scaptotrigona*) *xanthotrycha* (Moure) all collected from colonies found in a maximum radius of 100 kilometers from our bee yard (Rio Claro, S.P., Brazil). Specimens of *Apis mellifera adansonii* Latreille were collected in our apiary. This subspecies was introduced in Brazil in 1956 from queens collected in Tabora (Tanganyika) and Pretoria (South Africa). *Bombus* (*Fervidobombus*) *atratus* Franklin was found in a colony near our laboratory. Specimens of *Trigona* (*Trigona*) *fulviventris guianae* Cockerell were obtained in Ilha Comprida, S.P., Brazil, in a semi-subterraneous nest. *Trigona* (*Oxytrigona*) *tataira* F. Smith and *Trifona* (*Cephalotrigona*) *capitata* F. Smith were given by Dr. Paulo Nogueira Neto (both colonies found in this same region). *Lestrimelitta* (*Lestrimelitta*) *limão* F. Smith was collected in Poços de Caldas, M.G., Brazil.

The use of the names *T. spinipes* and *T. amalthea* is in accordance with the recent revision of Moure (1960). The use of the subgenus *Melipona* (*Micheneria*) is in accordance to the paper of Lopes and Kerr (1962).

Workers and, when possible, queens were dissected under a Zeiss stereoscope; drawings were made with a Zeiss camera lucida, and photographs with a Zeiss photomicroscope. The fixative used was Dietrich's; the sac and atrophied glands (when exist-

² According to Moure (1961) the subspecies which inhabits Tanganyika is *Dactylurina staudingeri schmidti* (Stadelmann)

ing) were stained with hematoxylin-eosin, Nile green, methyl green, aceto-orcein. Sections (10μ) and whole mounts were made. Weighing was done in a torsion balance with precision of 0.1 mg.

OBSERVATIONS

Observations on three groups of bees are listed, each in a phylogenetic order.

Bombus (Fervidobombus) atratus (workers). We dissected three workers, one of which had functional ovary, full of eggs in its eight ovarioles (four in each ovary). All three workers had the spermatheca without spermatozoa. The sting accessories, Dufour gland (or basic gland), acid gland and sac of the acid gland, do not differ consistently from the description made by Bordas (1895) for *Bombus (Agrobombus) muscorum* Fabricius and *Bombus (Pyrobombus) pratorum* Linné.

A schematic drawing of *B. (F.) atratus* showing the sting apparatus is seen in Fig. 1.

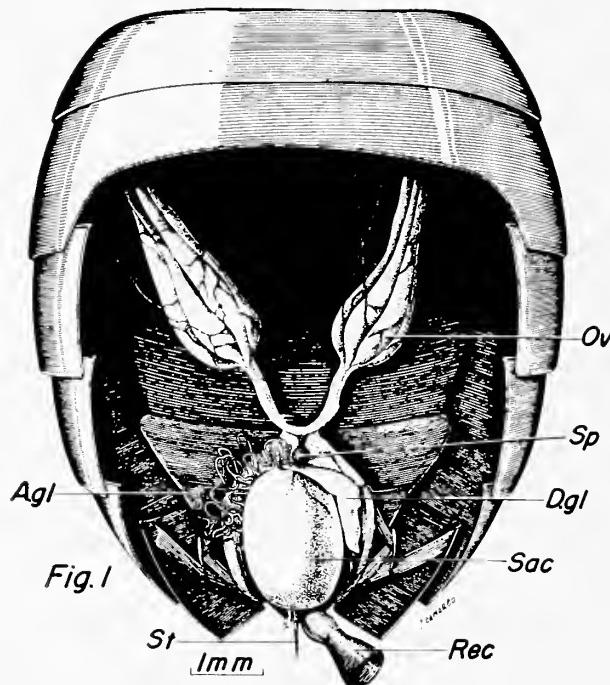


Fig. 1—Sting glands of *Bombus (Fervidobombus) atratus* Franklin. A.gl. = Acid glands, D.gl. = Dufour glands, Ov = ovaries, Sac = poison sac, St = sting, Sp = spermatheca, Rec = rectum.

According to Bordas (o.c.) the acid gland is composed of two thin cylindric and filiform tubes, that unite in a short common trunk. In our material this acid gland was more branched,

i.e., four tubes unite in two and these two in one short trunk. Sometimes one or two very short branches are found laterally attached to these four tubes (in one bee we counted nine branches). Histologically these tubes are composed of secretory cells around a canal lined by a thin membrane (Fig. 2). Several canalicules

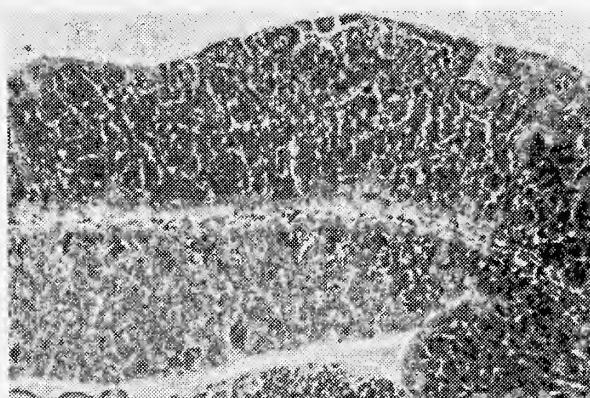


Fig. 2—Acid gland of *Bombus (F.) atratus* Franklin. Longitudinal view of small section of acid gland, showing central canal which collects the secretion (Photographed with phase contrast).

collected the secretion of the cells and released it in the central canal (Fig. 3). These canalicules in the anterior part of the

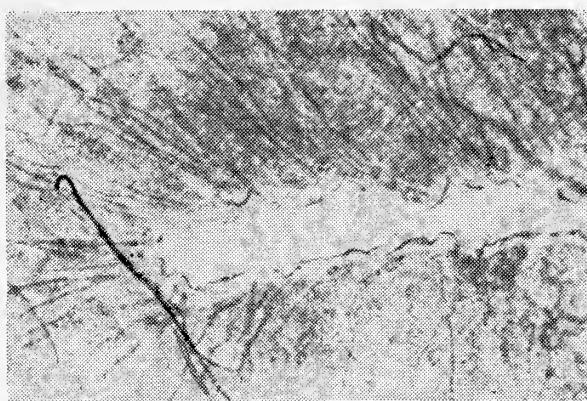


Fig. 3—Anterior end of the acid gland of *Bombus (Fervidobombus) atratus* Franklin. Region of greater secretory activity. Taken without phase contrast to show enormous quantity of canalicules opening into central canal (aceto-orcein smear).

sac are very thick and short. However, in the tubular acid gland they become thinner and longer toward the anterior part of the gland. The most active secretory cells are the ones in the distal end where one can see thousands of secretory cells, each with its respective thin canalicule (Fig. 3). The inner membrane shows the perforations of the canalicules.

Histologically the ovoid poison sac of *Bombus (Fervidobombus) atratus* is made by an external transparent membrane, an intima membrane and between these two, in about $\frac{1}{3}$ of the sac, a glandular epithelium, formed by a group of secretory cells different from the acid gland. To increase the secretory surface these cells are assembled in outfoldings (Fig. 4).

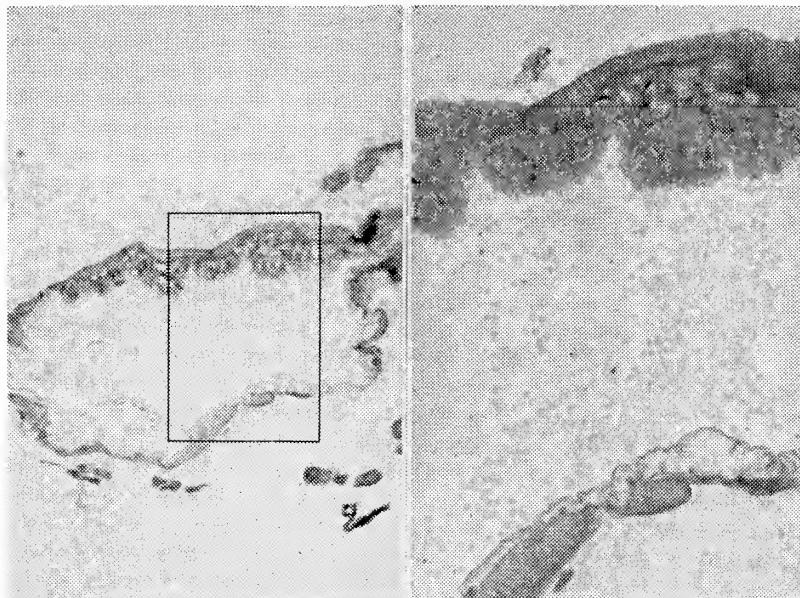


Fig. 4—Transverse section of poison sac *Bombus (Fervidobombus) atratus* Franklin. Approximately the section which passes in middle of sac. Note secretory epithelium in upper part. Left side shows the section practically complete. Right side shows framed part for easy comparison of secretory with the non secretory membranes.

The Dufour gland is also full of outfoldings, but distinct from those of the acid sac (Fig. 5). These villosities are much longer

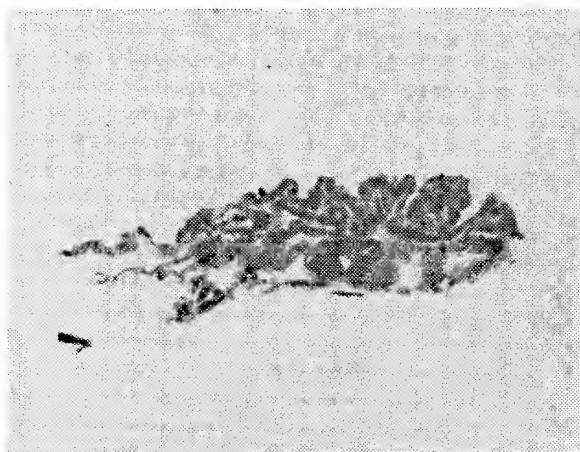


Fig. 5—Dufour gland of *Bombus (Fervidobombus) atratus* Franklin, transverse section, showing outfoldings distinct from villosities found in poison sac (Ref. Fig. 4).

and formed by smaller and more uniform cells. This gland of *B. atratus* does not differ from descriptions of other authors.

Apis florea (workers). The acid gland and poison sac do not differ consistently from those already described for *Bombus*, the differences being that there are only two branches in the acid gland and no villosities in the sac. The Dufour gland, however, is more developed than in *Apis mellifera*. (Fig. 6.)

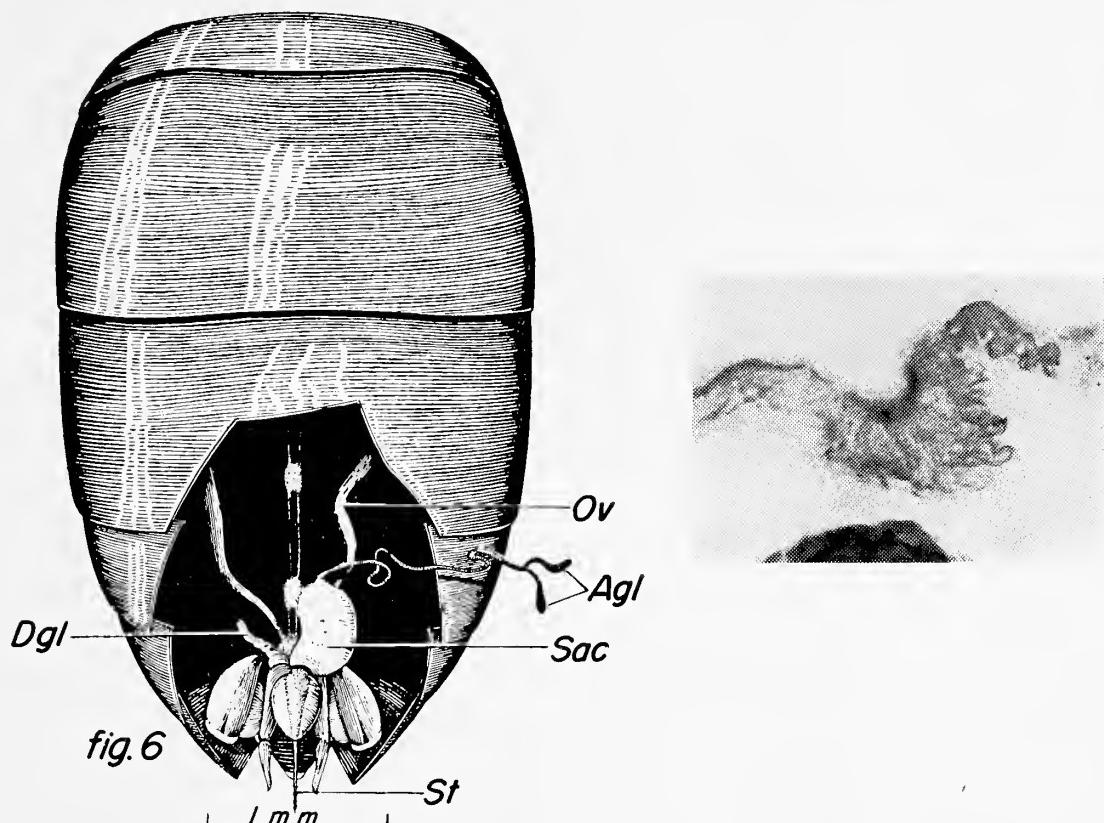


Fig. 6 (left)—Sting glands of *Apis florea* Fabricius. A.gl.=acid gland, D.Gl.=Dufour gland, Ov.=ovary, Sac=poison sac, St=sting. The Dufour gland more developed than in *Apis mellifera* (definitely more *Bombus*-like than *mellifera*).

Fig. 7 (right)—Small portion of cross section of poison sac of *Apis dorsata*, showing two membranes, the internal with anucleated villosities, having no secretory activity. The darker spot is dense secretion stored in sac.

Apis dorsata (workers). The sac is full of a dense secretion, darker than *A. florea* or *A. mellifera*. This may be the answer as to why its sting hurts more than other *Apis* species. In sections it was seen that the secretion absorbed more eosin than the secretion of other species. Higher absorption is also observed in every section of the acid gland in the central canal. The

Dufour gland is also well developed. No secretory villoosity was seen in the sac of the acid gland (Fig. 7). Anatomy and histology do not differ from *Apis mellifera*. (Fig. 8).

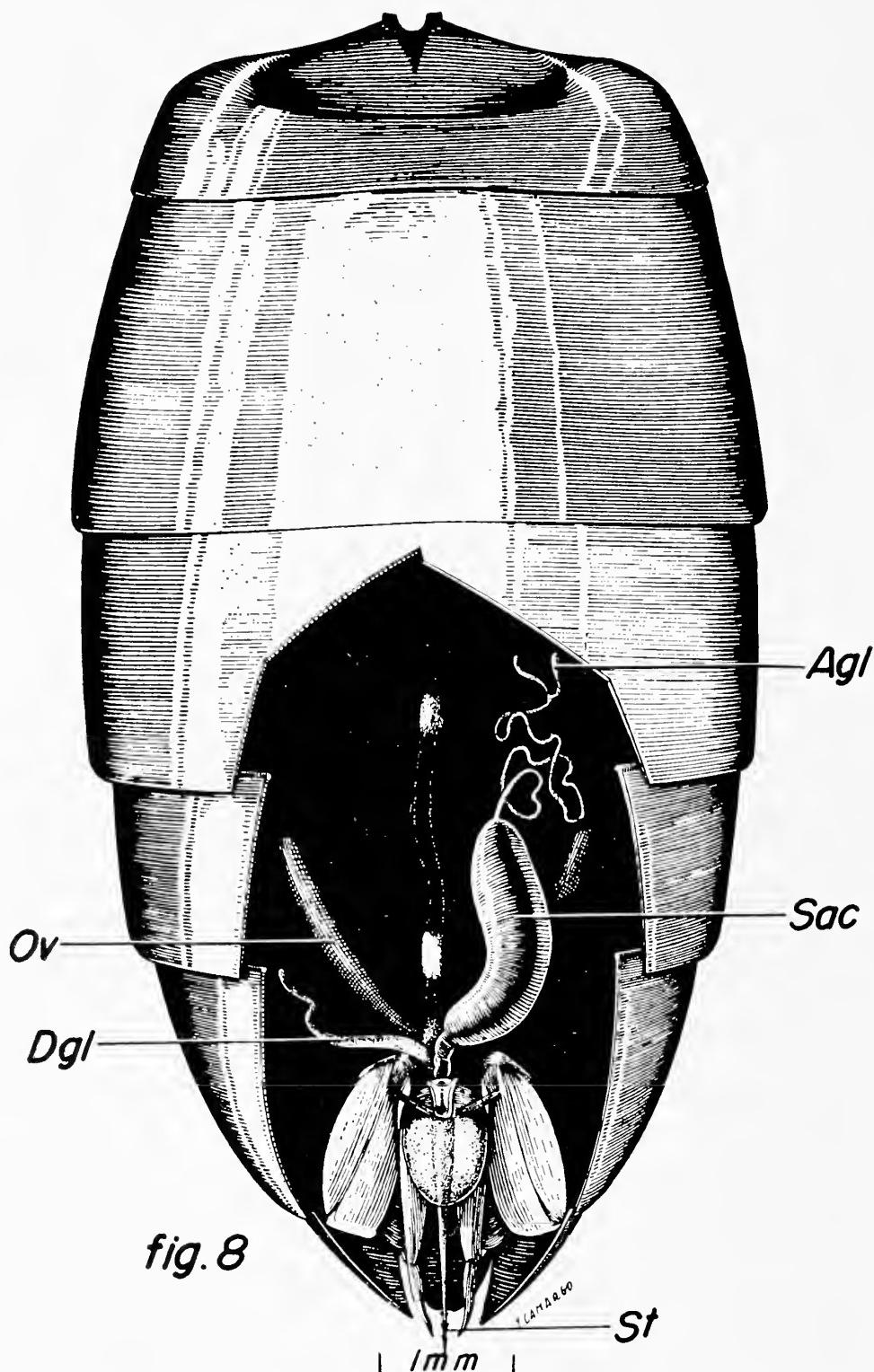


Fig. 8—Sting accessories of *Apis dorsata* Fabricius. Legend as in Fig. 1 and 6. The Dufour gland is also Bombus-like when compared with *mellifera*.

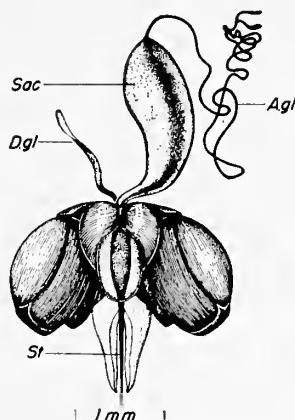


Fig. 9—Sting accessories of *Apis mellifera adansonii*. Legend as in Fig. 1 and 6.

Apis mellifera adansonii (workers and queens). The sting accessories do not differ (Fig. 9) from the description of *Apis mellifera mellifera* and *Apis mellifera ligustica* by Carlet (1890), Trojan (1930), Snodgrass (1956) and others. It is interesting that the acid gland, from the poison sac to the bifurcation, is much shorter in the queen than in the worker. The histology does not differ in principle (Fig. 10) from what is seen in

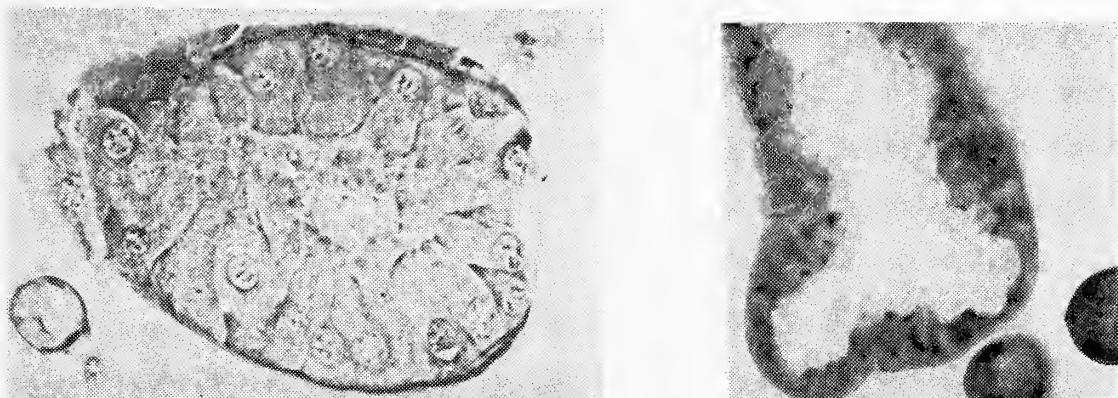


Fig. 10 (left)—Cross section of acid gland of *Apis mellifera adansonii* showing secretory cells of region with low secretory action.

Fig. 11 (right)—Cross section of the poison sac of *Apis mellifera adansonii* Latreille in anterior region, nearer acid gland. Poison sac merely a dilatation of acid gland. External membrane shown with layer of cells of the secretory type between.

Bombus atratus. The sac does not have secretory villosities (Fig. 11).

Meliponula bocandei (workers). All workers used were either field bees or guard bees.

It has an enormous u-shaped sac (Fig. 12). Six of the dis-

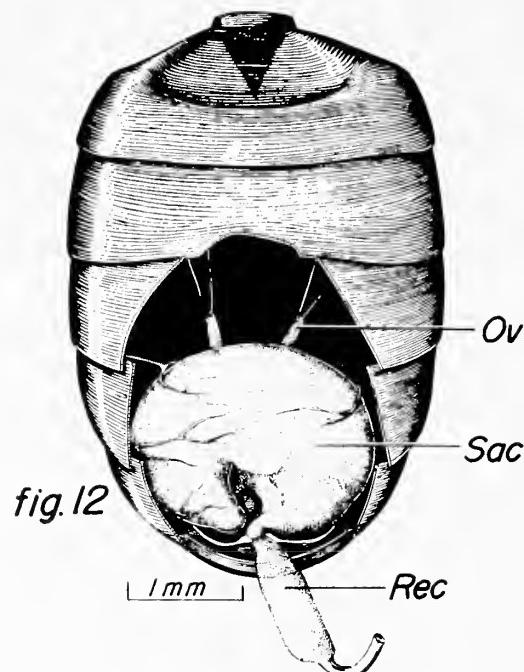


Fig. 12—Abdomen of *Meliponula bocandei* (Spinola) showing huge sac. Acid gland and Dufour gland lacking. Picture does not show sac at maximum volume, which can be about $\frac{1}{3}$ greater. Ov = ovary, Rec = rectum, Sac = sac corresponding to poison sac of *Apis* and *Bombus*.

sected bees had this sac completely full of an oily liquid, non-miscible with water. However 3 workers had it only partially full. The position of the exit of this sac is the same as in *Apis mellifera*, i.e., between the rectum and the main oviduct.

Histological sections showed that the sac had basically the same organization as that of *Bombus atratus*, i.e., a thin external membrane, a median layer of secretory cells and an internal intima membrane. The secretory epithelium increased its surface considerably, forming outfoldings, to compensate for the lack of more specialized secretory cells (Fig. 13). Several of



Fig. 13—Small portion of section of sac of *Meliponula bocandei* (Spinola) showing external membrane and villosities of secretory epithelium. Epithelium similar to *Bombus* (*Fervidobombus*) *atratus* Franklin shown in Fig. 4, only more developed.

the secretory cells have large vacuoles (Fig. 14), indicating secre-



Fig. 14—One outfolding of sac of *Meliponula bocandei* (*Spinola*) showing secretory cells full of vacuoles and nuclei. The intima membrane penetrates among the cells, possibly to increase transfer of secretion to lumen.

tory activity. The internal membrane is more delicate than the ones found in *Bombus* or *Apis* and of variable thickness.

Trigona (Frieseomelitta) freiremaiai (workers). Six field bees were used. The sac is well developed, and bent to the left (Figs. 15 and 16). The gland is not as developed as in *Melipon-*

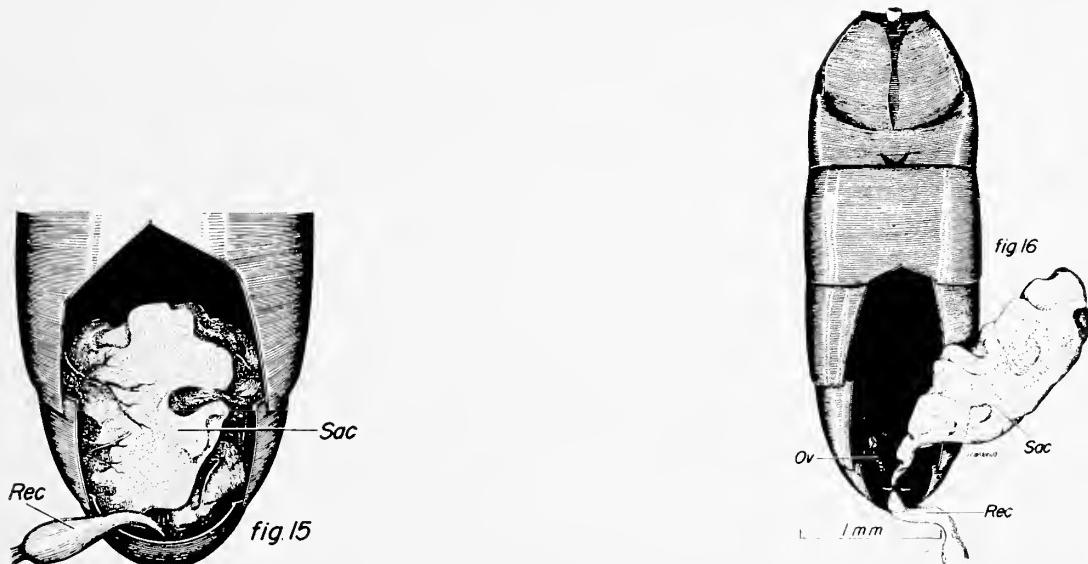


Fig. 15—Sac of *Trigona (Frieseomelitta) freiremaiai* Moure in natural position. (Refer. 1 sac unfolded in Fig. 16). Rec = rectum, Sac = sac corresponding to poison sac of *Apis* and *Bombus*.

Fig. 16—Sac of *Trigona (Frieseomelitta) freiremaiai* Moure unfolded to show enormous size. Legend as in Fig. 1 and 12.

ula, but it had more foldings.

The histology is similar to that of *Meliponula bocandei*, but the villous processes were smaller and less frequent than in that species (Fig. 17). There are no canalicules linking the cells to



Fig. 17—Cross section of sac of *Trigona (Friesomelitta) freiremaiai* Moure showing a great number of foldings and one villosity. Vilosity shown in detail Fig. 18. Sac possesses two membranes, one external and an intima. Among them secretory cells seen surrounded by intima membrane. Refer: Fig. 19.

the lumen, however the membrane involves each secretory cell in such a way that diffusion of the liquid is easy. Note vilosity of secretory cells (Fig. 18) and secretory cells in the wall (Fig. 19).

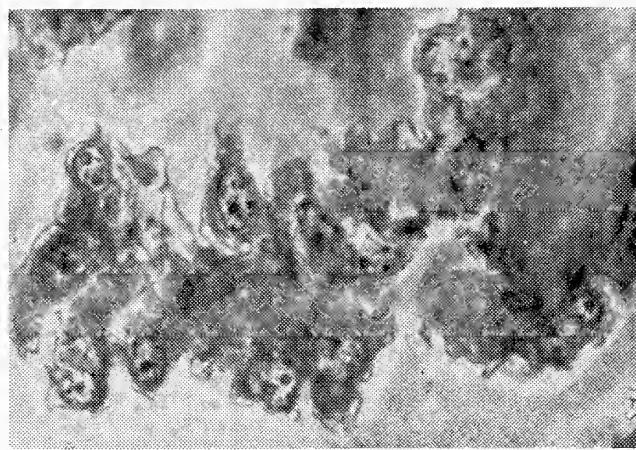


Fig. 18—Vilosity within the upper square (a) of Fig. 17. (Phase contrast).

Trigona (Nannotrigona) testaceicornis (workers and two queens). Workers had a large sac filled with an oily liquid.



Fig. 19—Secretory cells in lower square (b) of Fig. 17. (Phase contrast).

Two virgin queens examined also possessed a large sac. These queens had not yet emerged but were about to do so in two to three days. Both queens had empty sacs. No villosities were found in the sacs of workers or queens, although secretory cells could be seen in between the sac membranes.

Trigona (Plebeia) droryana (workers). The workers examined did not differ from the *T. (N.) testaceicornis*, i.e., they had a large sac (Fig. 20). The secretory cells are not specialized (Fig. 21).



Fig. 20—Sac of *Trigona (Plebeia) droryana* Friese. When completely full can be twice as large.

Fig. 21—About $\frac{1}{5}$ of cross section of sac of *Trigona (Plebeia) droryana* (Frieseomelitta.) Between dark external membrane and light intima membrane is layer of secretory cells that do not seem as specialized as in Fig. 13 and 17.

Trigona (Plebeia) schrottkyi (workers). The workers possessed sacs similar to *T. (P.) droryana*. (Fig. 22).



Fig. 22—Sac of *Trigona (Plebeia) schrottkyi* Ov = ovary, Rec = rectum, Sac = sac homologous to poison sac of stinging bees.

Fig. 23—Vestigial sac of *Trigona (Oxytrigona) tataira* F. Smith. Ov = ovary, Sac = vestigial sac, Sp = spermatheca.

Trigona (Partamona) cupira helleri (workers). The workers showed either no sac or a small vestigial sac, with little inside.

Trigona (Tetragonisca) jaty (workers). The workers possess a small sac, smaller than *T. (P.) droryana*, but not vestigial as *T. (O.) tataira*.

Dactylurina staudingeri (workers). The workers of this species possess a relatively large sac (homologous to the poison sac) but with a few patches of secretory layer. In fact in the section where the secretory epithelium was larger was only 1/9 of the total section (Fig. 24). A few villosities were found

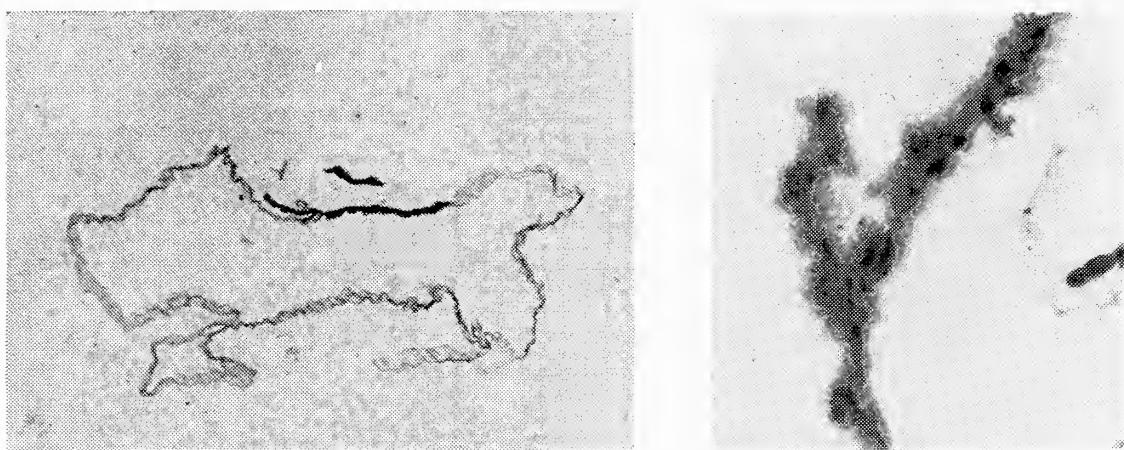


Fig. 24—Cross section of the sac of *Dactylurina staudingeri* (Gribodo) showing secretory epithelium (dark) covering 1/9 of whole section.

Fig. 25—Villosity of sac of *Dactylurina staudingeri* (Gribodo). Type of sac and of villosity differ from all others found in meliponids.

(Fig. 25) but of a type different of *M. bocandei* or *T. feiremaiai*.

Trigona (Oxytrigona) tataira (10 workers). The vestigial sac is smaller than the vestigial spermatheca (Fig. 23).

Trigona (Trigona) hyalinata (workers). The workers do not possess sting accessories.

Trigona (Trigona) amalthea (workers). The workers do not possess sting accessories.

Trigona (Trigona) fulviventris subspecies *guianae* (workers). The workers do not possess sting accessories.

Trigona (Trigona) spinipes (workers). Two workers showed a vestigial sac, about 350μ long and 40μ wide. One worker did not have a sac.

Trigona (Scaptotrigona) postica (workers, virgin queens, old queen). All workers examined showed no sign of gland or sac (Fig. 26). However the virgin has a well developed sac (Fig.

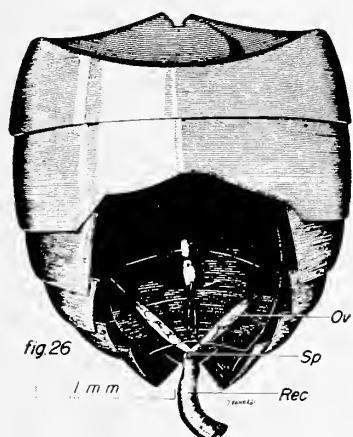
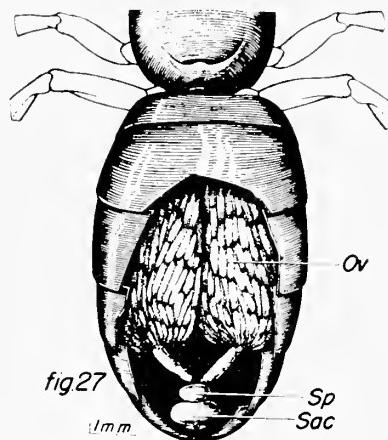


Fig. 26—*Trigona (Scaptotrigona) postica* Latreille shows no sign of poison sac. Ov = ovary, Rec = Rectum, Sp = spermatheca.

Fig. 27.—Queen of *Trigona (Scaptotrigona) postica* Latreille with developed sac. In virgin queen sac 4× bigger than in gravid queen as above. Ov = ovary, Sac = sac homologous to the poison sac, Sp = spermatheca.



27). This queen was about 25 days old and had come from a mother hive to a new location, where bees were founding a new home (for swarming in stingless bees see Nogueira Neto 1950). The sac was full of an oily liquid. The old queen had this sac much smaller than the virgin, being no greater than the spermatheca.

Trigona (Scaptotrigona) xanthotricha (workers and queen). Workers had no sac nor glands. A virgin queen (17 days old just being killed by her sisters, workers of a queen-right colony) was fixed and dissected. She had the same structures as *T. (S.)*

postica, except that the sac was not completely filled.

Trigona (Scaptotrigona) bipunctata (workers and queen). Workers with no sting accessories. A virgin queen, 10 days old, had structures like *T. (S.) postica*, with its sac full of an oily liquid. The histology shows the sac full of villosities similar to the *Meliponula bocandei* (Figs. 28, 29, 30).

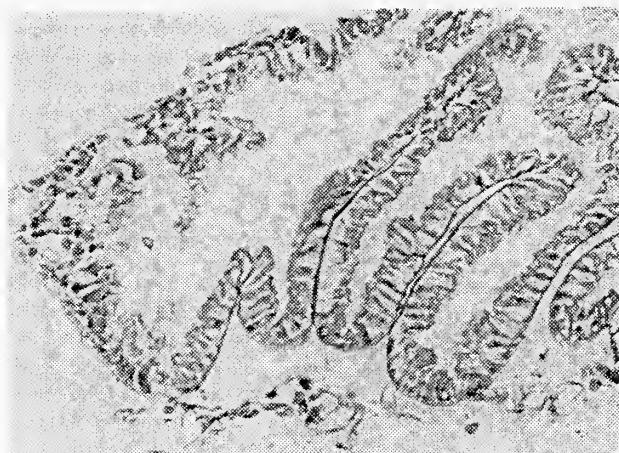


Fig. 28—Cross section of sac of virgin queen of *Trigona (Scaptotrigona) postica* Latreille, showing primitive condition, similar to *Meliponula bocandei* (Gribodo), i.e., secretory epithelium formed by numerous villosities.

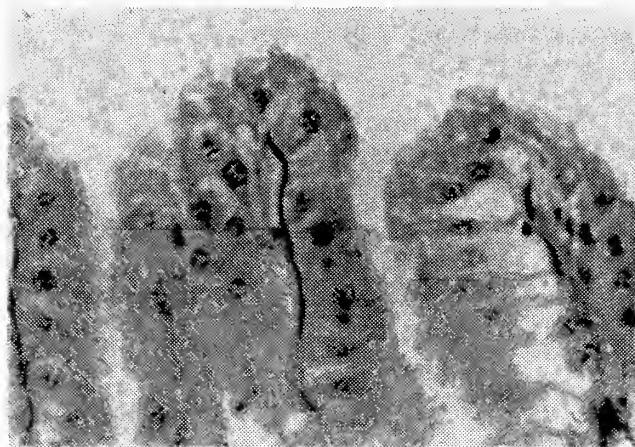


Fig. 29—Two villosities of sac of *Trigona (Scaptotrigona) postica* virgin queen in left, cells in no great secretory activity and in right cells with vacuoles full of secretion. These groups of cells are shown in Fig. 30.

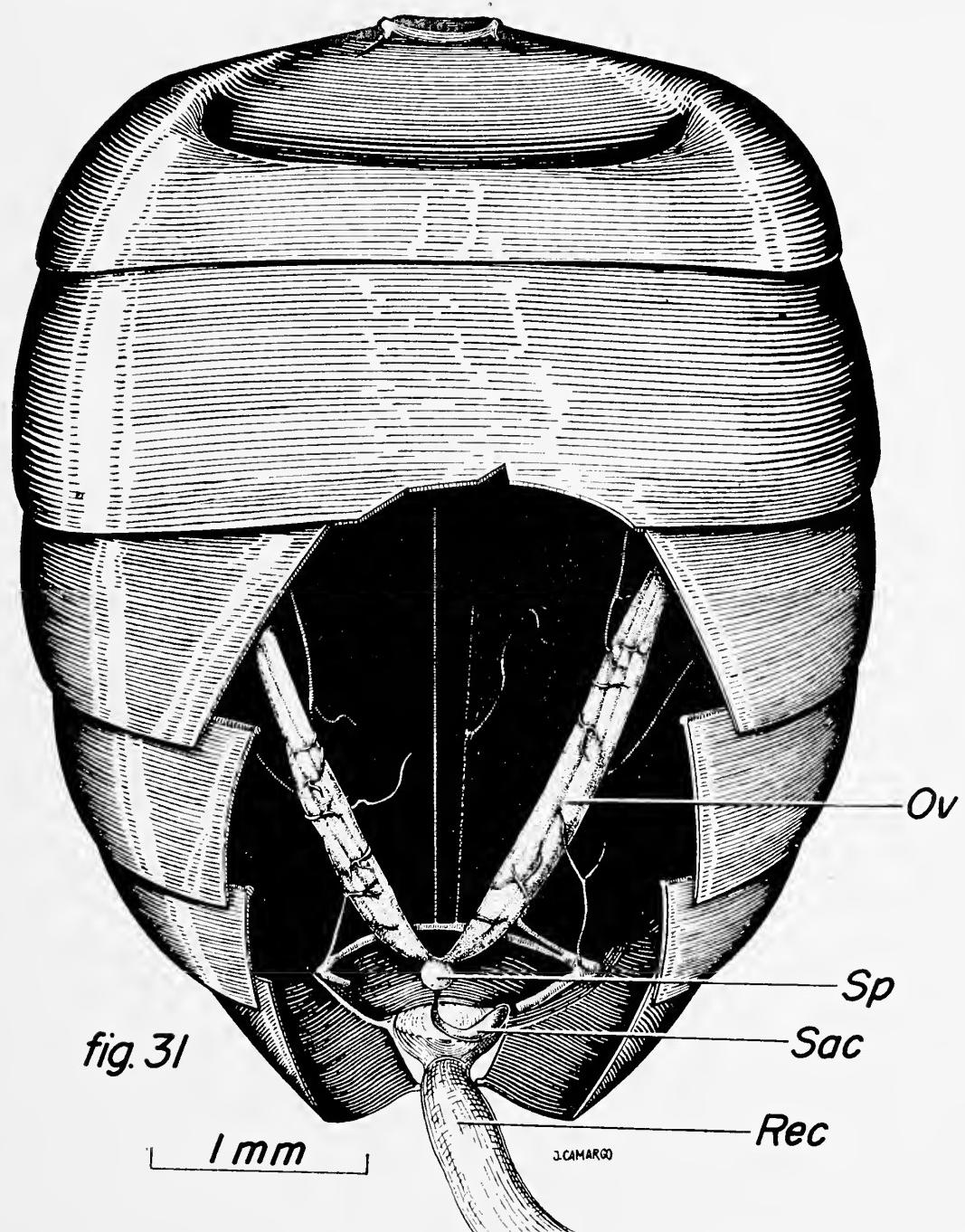
Trigona (Cephalotrigona) capitata (workers). Workers show no sac.

Melipona (Micheneria) marginata (workers). Workers with very small sac.

Fig. 31—Vestigial poison sac of *Melipona (Melipona) quadrifasciata* Lepeletier. Ov = ovary, Rec = rectum, Sac = vestigial poison sac, Sp = spermatheca. →



Fig. 30—Villosity of secretory cells with vacuoles full of secretion of sac of virgin queen of *Trigona (Scaptotrigona) postica*. Nuclei compressed to one side of cell. (Phase contrast).



Melipona (Melipona) quadrifasciata (workers and virgin queen). Workers have many variable structures although all of them small and vestigial. In about $\frac{1}{3}$ of the workers the sac was extremely small (Fig. 31) in another $\frac{1}{3}$ it was a little larger,

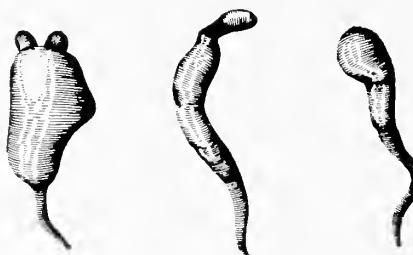


Fig. 32—Three types of vestigial sacs found in *Melipona (Melipona) quadrifasciata* Lep. First sac has two protuberances which in spite of being vestigial are homologous to two acid glands of *Bombus* and *Apis*.

and in the last $\frac{1}{3}$ it was pear shaped with two vestigial acid glands in the top (Fig. 32). The liquid in these larger sacs was jelly-like. Histologically, the sac was made of two membranes with a layer of cells between them.

Two virgin queens were examined. Their sacs were cylindrical, two to four times bigger than the largest worker sac seen. None of the queen sacs had vestigial glands.

Melipona (Melipona) rufiventris (workers and queens). The workers and queens have a vestigial sac. The sac of the workers compares with the smallest of *M. (M.) quadrifasciata*, but the queens have the vestigial sac equal to that of *M. quadrifasciata*.

Lestrimelitta (Lestrimelitta) limao (workers). No sign of poison sac.

DISCUSSION

Study of the morphology of the acid gland shows that the primitive condition for Apidae is the one preserved in *Psithyrus rupestris* in which each acid gland opens directly into the poison sac (Bordas 1895). The second step is found in *Bombus*, where these glands are united in a common trunk opening into the sac. *Bombus (Lapidariobombus) lapidarius* Linné, *Bombus Pyrobombus) hypnorum* Linné, *Bombus (Agrobombus) muscorum* Fabricius and *Bombus sylvarum* are more primitive (Bordas found the two glands uniting 3 to 4 mm from the poison sac)

and *Bombus (Hortobombus) hortorum* Linné, *Bombus (Pyrobombus) pratorum* and *Bombus (Pomobombus) pomorum* Panzer are more evolved (Bordas found that the union occurs 10 to 20 mm from the sac) in relation to the acid gland. The primitiveness of this characteristic is strengthened by the fact that the *Apis* queen has a shorter common trunk for the acid gland than the workers (it is common to see primitive characters possessed by queens of social bees). Finally, the worker of *Apis mellifera* has the longest common trunk (and the shortest individual branches of all). The two protuberances found in the poison sac of *Melipona quadrifasciata* indicate that meliponid of the primitive type may have been similar to *Psithyrus* or to some primitive *Bombus*.

The poison sac of *Apis florea*, *Apis dorsata* and *Apis mellifera* does not show secretory cells assembled in a villous epithelium. However, they were found by us in *Bombus atratus*, in workers of *Meliponula bocandei* and *Trigona (Frieseomelitta) freiremaiai* and in queens of *T. postica*. The secretion of *Meliponula bocandei* is not caustic which suggests that this secretion has some other function. In *Trigona (Nannotrigona) testaceicornis* and *Trigona (Plebeia) droryana* these cells no longer form out-foldings but still exist in great quantity in a non-stratified epithelium. In other groups of stingless bees few cells exist in the sac due to its small size.

Bees of the genus *Apis* lose their stings after they use it in a victim, therefore an enemy attack can deplete a colony greatly, leaving it weak. Weak colonies fail to reproduce. It is, therefore, conceivable that new methods of defense have evolved that would not take a heavy colony toll. Stingless bees are not defenseless but have according to Kerr (1950, 1951) at least thirteen different means of keeping enemies out. These include:

1. Deposits of wax mixed with vegetable gums or gums and resins, to adhere to the enemy in a fight or to plaster an enemy getting inside the hive. This system is used by the subgenera *Plebeia*, *Tetragona*, *Trigona*, *Tetragonisca*, and others.
2. Robust mandible sometimes reinforced with teeth able to cut an enemy apart are characteristic of the *Melipona* genus and

of the *Trigona* subgenus (species: *spinipes*, *amalthea*, *hyalinata*).

3. Unpleasant taste and smell. This method is considered the most important by Marianno Filho (1910). Species of the subgenera: *Trigona*, *Scaptotrigona*, *Geotrigona* and many *Melipona* species have this property.

4. Massive attack to repel an intruder, penetrating nostrils and ears. Such a method is used by *Scaptotrigona*, *Oxytrigona*, *Trigona*, *Partamona*, and other subgenera.

5. Large number of workers. Huge colonies of more than 200,000 workers are found in many species such as *T. (T.) jaty*, *T. (S.) pectoralis* Dalla Torre, *T. (T.) hyalinata*, *T. (T.) cupira*, and others.

6. Entrance fitted to allow only one bee in or out. Such a method increases the defense system considerably, and it is used by almost all *Melipona* and many *Trigona*.

7. Closing the entrance as sunset with wax and reopening it in the morning. Such a system is used by weak colonies in general.

8. Blocking the entrance with wax or resins. According to Fiebrig (in Maidl, 1934) workers of *Lestrimelitta limao* F. Smith placed in an elaborated entrance tube small pieces or blocks of wax and resin to keep ants from getting in. When an attack is over the bees remove them. Maidl (1934) cites that *Trigona (Lophotrigona) canifrons* Smith workers build a ring of resin surrounding the entrance, which is constantly renewed. We noted that some species of the subgenus *Plebeia* have the same behavior.

9. Some species of stingless bees such as *T. (F.) silvestri* Friese appear dead when touched by a strong enemy (personal communication of Dr. Nogueira Neto).

10. Camouflage of the nest or of the nest entrance. This is done by several species, such as *Melipona (M.) quadrifasciata*, *Trigona (F.) silvestrii*, *Trigona (Plebeia) cupira*, and others.

11. Mimicry. Kerr (1951) cites 9 cases of mimicry where the stingless bee copies a bee or a wasp possessing a strong sting.

12. *Trigona (Oxytrigona) tataira* uses its mandibular glands to inflict on the enemy, especially mammals, a terrible "burning," due to the action of a caustic secretion (Kerr and Cruz 1961).

13. *Trigona (H.) braunsi* defends itself against a *Lestrimelitta*

(*Cleptotrigona*) *cubiceps* attack by pouring honey on the invaders (Portugal-Araújo 1958).

These methods, made stings obsolete and mutations to diminish or abolish stings become established in the primitive populations. However, the sting glands and accessories had no strong selective disadvantage aside from the space they occupied and so were selected against much more slowly.

The small basic gland (or gland of Dufour) disappeared completely. Histologically the sac that remains in some stingless bee species is homologous to the acid gland sac. This sac is merely a dilatation of the acid gland's posterior part.

The drawing of Dufour (1841), Carlet (1890) and Bordas (1895) are in error concerning the external opening of the Dufour gland (basic or alkaline gland). Our slides show that Trojan (1930) is correct, in that this gland opens into the sting chamber, below the sting (Fig. 33). Trojan suggests that this

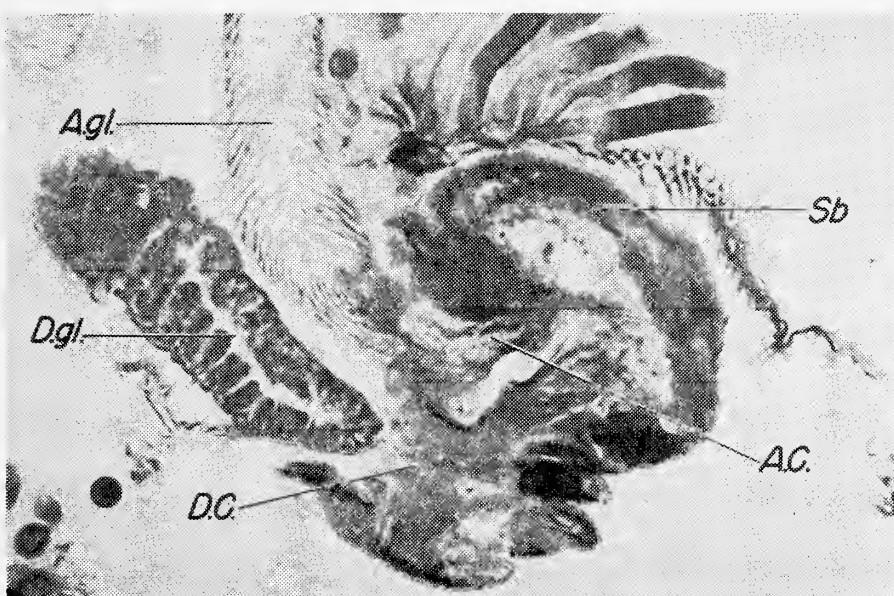
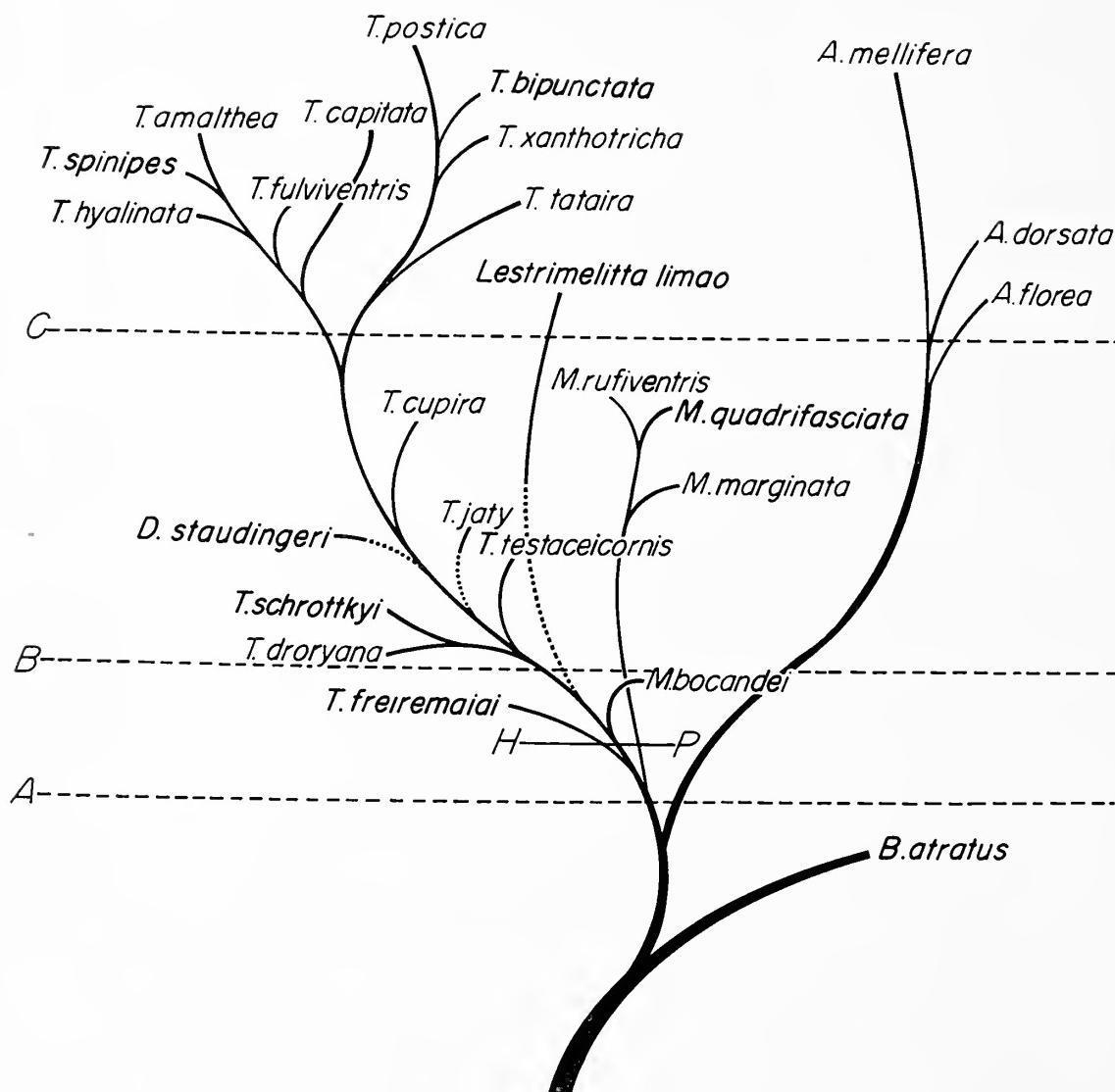


Fig. 33—Dufour and acid glands of *Apis mellifera adansonii* Latreille, in single section (10μ). Dufour gland (D.gl.) opens below sting chamber and acid gland (A.gl.) opens in sting bulb. A.gl. = acid gland, A.C. = Acid gland canal, D.gl. = Dufour gland, D.C. = Dufour gland canal, Sb = sting bulb.

gland is used by the queens, to provide a protective covering for the eggs issuing from the vagina and serving as an adhesive for attaching the eggs to the wall of the comb cell. This idea agrees with our following observations: a) The Dufour gland is more

developed in *A. florea* and *A. dorsata* than in *A. mellifera*. This may be due to the fact that these two species build combs in the open air, subjected to the direct impact of the rain. Notwithstanding these bees provide a good defense of the alveoli, covering them with their water repellent bodies. It is more likely that such eggs need more protection and a stronger adhesive than *A. mellifera*. b) The Dufour gland completely disappeared in the meliponids (stingless bees). It is completely unnecessary in these bees, because the workers fill an alveolus with food (liquid in all species except *Meliponula bocandei*) and the queen lays an egg on it. Immediately the bees close the alveolus with wax. Therefore no need to fasten the egg to any surface exists.

There are over 300 species of stingless bees (according to Prof. J. S. Moure's files, added with some *Melipona* subspecies that we found to be good isolated species) distributed in groups



with different levels of evolution. According to their nests (Kerr and Laidlaw 1956), their system of communication (Kerr 1961), their mandible glands (Cruz 1960, Kerr and Cruz 1961), and their cytology (Kerr 1962, unp.) a diagrammatic representation (Fig. 34) shows the relative evolutionary levels reached by each species. The relative size of the sting poison sac closely follows this diagram. In fact, *Trigona freiremaiai* and *Meliponula bocandei* have the largest sacs (these two bees are so primitive that they do not make combs but have their brood cells arranged in clusters, similar to some *Bombus* species); *Trigona (Nannotrigona) testaceicornis*, *Trigona (Plebeia) schrottkyi* and *Trigona (Plebeia) droryana* have well developed glands, but not very large. *Dactylurina staudingeri* has a large sac but provided with few secretory patches. *Melipona* species and *Trigona (Tetragonisca) jaty* have vestigial sacs; it is evident that in *Melipona quadrifasciata* there is a great variation in size and shape indicative of an unstable genetic constitution; *T. jaty* has glands somewhat larger. Vestigial sacs, and sometimes no sacs are found in bees like *Trigona (Partamona) cupira*, *Trigona (Trigona) spinipes*, *Trigona (Trigona) fulviventris*, *Trigona (Trigona) amalthea*, *Trigona (Trigona) hyalinata*, *Trigona (Oxytrigona) tataira*, *Trigona (Cephalotrigona) capitata*, *Lestrimelitta* (Les-

Fig. 34—*Tree of evolutionary level and possible relationship.* Below line A no communication exists and each queen found new colony with no help of workers. Between lines A and B species have primitive communication system; the *Friesomelitta* group has tubes for pollen like superior *Bombus*, and chromosome number in $n=9$; the *Meliponula* species has dried food. Below line B only cluster type of cell arrangement is found. Line H-P indicates that branches originating above it have $n=18$ chromosomes (or 17 when reduction through translocation took place). Between lines B and C species with good alarming system (for communication) are found, and some, like *T. cupira*, and superior *Melipona* have some means of directional communication. Some species still have cluster type of cell arrangement and may or may not have involuerum. Species above C line have precise type of communications, and nests are quite evolved.

Degeneration of sting gland sac follows: Below line A acid gland and Dufour gland are well developed. Sting sac of *Bombus* has few villosities of secretory cells. Above line A no meliponid found with Dufour gland. Between lines A and B meliponid species have well developed sting sac full of villosities which contain secretory cells. Between B and C several degrees of degeneration of sac homologous to acid gland sac are found. Above line C vestigial sac or no sac at all is found among meliponids, and no secretory vilosity is found in sac of *Apis* species.

trimelitta) limao, *Trigona (Scaptotrigona) bipunctata* do not show signs of these sting accessories in the worker. However in *T. (S.) bipunctata*⁽³⁾, *T. (S.) postica* and *T. (S.) xanthotricha*, whose queens were examined this sac was well developed. Why would the queen show a well developed gland and the worker none? Bees constitute the best didactic example against Lamarckism and Lisenkoism. The genic constitution of the queen is mainly selected for genes that will benefit the workers so the entire colony becomes more fit. Extra weight of an unnecessary poison sac which would not be a serious burden to a queen because of her domestic life would mean a lot of extra work to a worker which has to fly an average of 10 to 20 kilometers a day. A worker of *Apis mellifera adansonii* weighs an average of 67.0 mg (s.d. 5.5) and can carry in its honey crop as much as 54.8 mg (s.d. 7.2) of nectar (personal communication of Mr. D. Beig); its acid gland, sac and sting weigh 4.0 mg, which is 6% of the body weight. A worker of *Meliponula bocandei* weighs 39.4 mg has a honey-sac capacity of 31.4 mg and its sting sac when full weighs 9.1 mg which is 29% of the total body weight. Therefore, genes will be selected that affect the worker sac. Whether these same genes do or do not affect the queen also, is irrelevant. In queens of *Melipona quadri-fasciata* the size of the sac is only two to five times greater than the average worker, but in the *Scaptotrigona* the difference is enormous (compare Fig. 26 and 27).

The evolution of the stingless and poison-gland-less condition in social bees provides an example of an orthogenetic series, in which evolution left alive all intermediate types and substantiates our explanation of a vestigial character.

ACKNOWLEDGEMENTS

We thank Prof. J. S. Moure for allowing us to use his files to determine the number of species of stingless bees; Dr. Robert Davis for correcting our English translation; Mr. Virgilio Portugal Araújo for giving us the specimens of *Meliponula bocandei*; to Dr. Paulo Nogueira Neto for specimens of *T.(O.)tataira* and *T.(C.)capitata*; Mr. D. Beig for information on

³ The virgin queen of *T.(S.)bipunctata* examined by us was secreting wax through her three last tergite connections. It was known (Drory 1873, 1874, 1877, Kerr 1951) that males of stingless bees secrete wax (unlike drones of *Apis mellifera*) but it was not known that a virgin queen can also do it.

A.m.adansonii taken from his experimental data; Dr. S. F. Sakagami, Prof. J. S. Moure and Dr. Carminda da Cruz Landim for valuable suggestions. The subgenus of *Bombus* was named according to Dr. S. F. Sakagami; All drawings were done by Mr. J. M. F. Camargo.

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Delayed Publication

The response from the South American co-workers of the late Herbert F. Schwarz in contributing to this issue of the *Journal* has been overwhelming. The magnificent cooperation and the fact that many papers were received late in the year, however, created a problem of publication. Since it was not possible to include all of the papers in this issue, the Editors and the Publication Committee reluctantly made the decision to carry over the following papers for Volume LXXI:

- Araujo, Virgilio de Portugal Subterranean Nests of Two African Stingless Bees
- Kerr, Warwick E., Amilton Ferreira and Neide Simões de Mattos Communication Among Stingless Bees—Additional data
- Landim, Carminda da Cruz Evaluation of the Wax and Scent Glands in the Apinae
- Sakagami, Shôichi On the Male of *Trigona (Tetragona) fimbriata* Smith
- Kerr, Warwick E. and Vilma Maule Geographic Distribution of Stingless Bees and its Implications.

Upon publication, each paper will be accompanied by a note indicating that it was submitted for inclusion in the HERBERT F. SCHWARZ MEMORIAL VOLUME.

MUTUALISM BETWEEN *TRIGONA COMPRESSA*
LATR. AND *CREMATOGASTER STOLLI* FOREL
(HYMENOPTERA: APIDAE)

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SANTA CRUZ, BOLIVIA

RECEIVED FOR PUBLICATION JANUARY 16, 1962

ABSTRACT

Every colony of the stingless bee, *T. compressa*, found by the author had surrounding it a colony of the ant, *C. stolli*. When the bee colony is broken into to obtain the honey, these carnivorous ants swarm out to attack the invader. However, the ants do not feed on any of the spilt honey nor do they attack the bees. The original arrangement is restored after a period of reorganization.

Schwartz (1948) refers to a colony of *Solenopsis geminata* (Fab.) living as a neighbor to a hive of *Trigona (Scaptotrigona) bipunctata*. The colonies were only neighbors, that is, there was complete separation between them. Nogueira-Neto (1953) cites a similar case, where two colonies, one of a bee and another of an ant were neighbors, the bee colony receiving considerable protection from the ants. The present note refers to observations in several colonies of the stingless bee *Trigona compressa* (Latr.) commonly known as "sombra de sucha", and the ant *Crematogaster stolli* (Forel).

In spite of being insectivorous these ants live in harmony with the bees. Bees of *Trigona compressa* are gentle and hard workers. Usually their nests contain a little over 1 liter of an agreeable, acid and odoriferous honey. A colony of these bees contains about 10,000 to 15,000 workers. Completely surrounding a natural hive of *T. compressa* one finds a nest of *Crematogaster stolli* ants. The anthill has a population twice or thrice that of the bees. Both bee and ant colonies have a single entrance divided by a fragile partition of wax and resins. The entrance for the bees is 4 cm, more conspicuous and 3 cm of diameter. The ants penetrate to the inferior part of the entrance and go down through a net of tunnels, in the tree trunk until penetrating the humiferous crest next to the tree base.

The most interesting fact is that every colony of *Trigona*

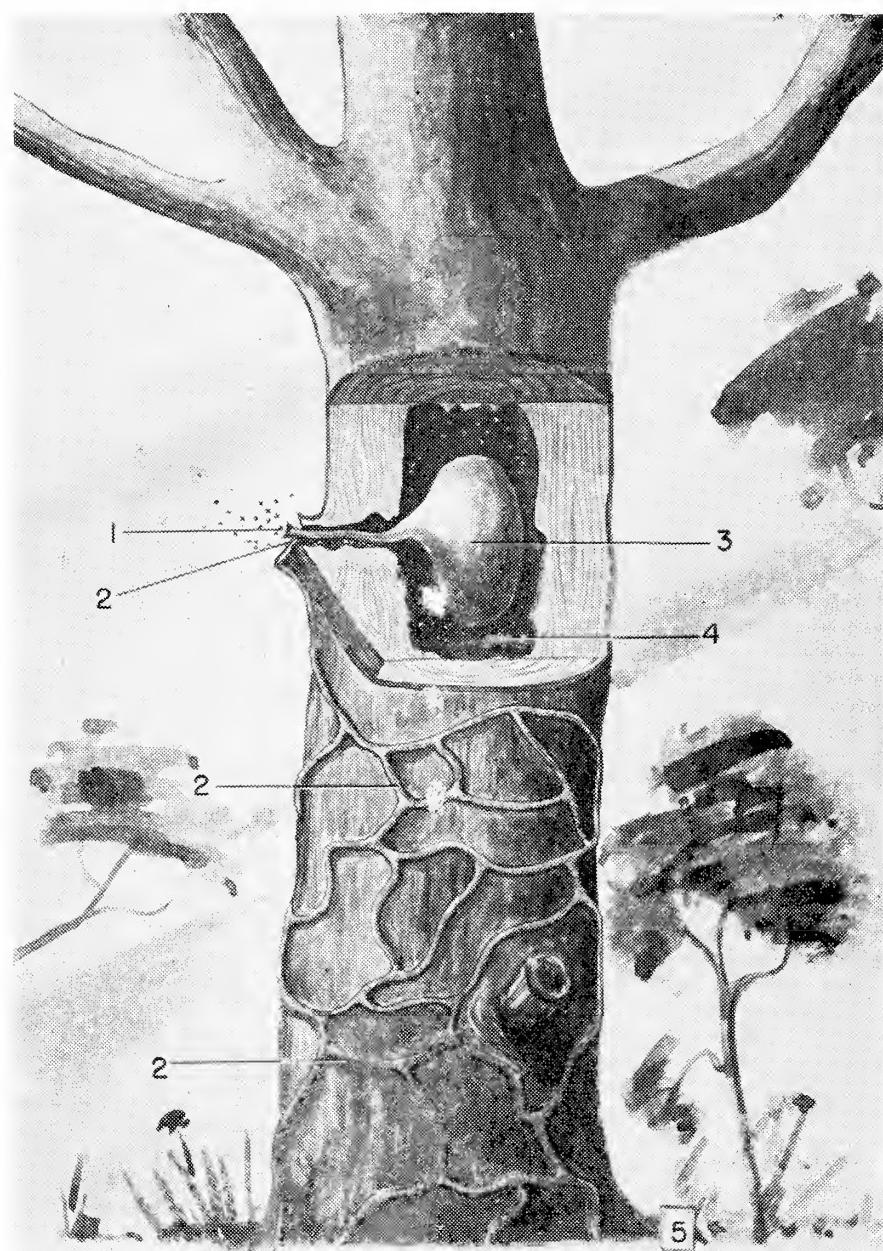


Fig. 1.—Scheme of nest of *Trigona compressa* and *Crematogaster stolli*:

1. Entrance to bee nest;
2. Tunnels from ant-hill leading to ground;
3. Bee colony;
4. Ant colony;
5. Humiferous soil.

compressa found by myself so far was associated with a colony of *Crematogaster stolli*.

When someone wants to collect the honey of these bees, at the first impact of the axe the ants become cross and practically cover the trunk with an ant sheet, furiously biting the invader. When the natural hive is opened, the ants never touch the spilled honey, nor the brood, neither the bees. If one allows time for

them to reorganize they will start all over again, in harmonic association.

The advantage that the bee colony obtains from this mutualism is obvious. However, it is not clear if the ants profit from this association. Figure 1 represents both nests in nature.

ACKNOWLEDGMENT

The illustration presented in this paper is the work of Mr. J. M. Camargo.

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A REVISION OF THE SUBGENUS *NOGUEIRAPIS*;
AN ARCHAIC GROUP OF STINGLESS BEES
(HYMENOPTERA: APIDAE)¹

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RECEIVED FOR PUBLICATION AUGUST 22, 1962

ABSTRACT

Nogueirapis represents a natural group of the genus *Trigona* and is regarded as a valid subgenus. Three species, *butteli*, *mirandula*, and *silacea*, this latter a fossil from the Middle Miocene amber of Chiapas, Mexico, are included in this subgenus. The affinities of subgenera are discussed, the evolution of the subgenus is considered, and the species are redescribed. The two living species are so similar, structurally, to the fossil one that they may be considered indirect descendants.

The subgenus *Nogueirapis* was erected by Moure in 1953 to include the species described by Friese as *Trigona butteli*, an apparently rare form from South America. Since the subgenus *Nogueirapis* was described (Moure, 1953), two more species have been included: (1) *Trigona mirandula* Cockerell, a rare species from Costa Rica and Gorgona Island, Colombia, that has passed unnoticed for more than forty years. It was rediscovered by Moure in 1959 when studying types and (2) *Trigona silacea* Wille, a fossil bee from the Middle Miocene amber of Chiapas, Mexico, described by the author (Wille, 1959). The similarity of the fossil form to the two living species is so close that it is possible that *T. mirandula* and *T. butteli* are indirect descendants from the fossil. The purpose of the present paper is to show this relationship and the possible phylogenetic arrangement of the species. Redescriptions of the species are also given. New descriptions have been greatly needed for *T. mirandula* and *T. butteli*, which were poorly described. As to *T. silacea*, new and better material was made available to the author, which helped in making a few minor corrections in the original description of *T. silacea*.

1. This study was aided by a grant from Sigma Xi.

2. Departamento de Entomología, Facultad de Agronomía, Universidad de Costa Rica.

Males and queens of these bees are unknown. However, there is one male among the fossil material that could be assigned to *Nogueirapis*. Unfortunately, the fossil is not well preserved, and it seems advisable at present to await further studies. The wing terminology follows that of Michener (1944).

COMMENTS ON THE GENERAL CLASSIFICATION OF THE STINGLESS BEES

Since *Nogueirapis* was erected by Moure as a subgenus of *Partamona*, a few remarks on the general classification of the stingless bees seem necessary. On the basis of morphology and biology, the stingless bees form a natural group in the subfamily Apinae. Notwithstanding important similarities, they are a diversified group, as might be expected in view of the number of included species, their wide geographic distribution, and their fairly long geological history. The need to divide them into different categories was early felt by several investigators. These groups have been given different taxonomic rank by various writers, and the number of genera and subgenera accepted has varied according to the authors. In the study of the group *Nogueirapis* the author has retained a more conservative view. Except for the genera *Lestrimelitta*, *Dactylurina*, *Meliponula* and *Melipona* there are advantages in retaining the stingless bees in a single genus, *Trigona*, instead of dividing them into some 32 genera. They have essentially similar biologies, and are similar in appearance and basic morphology, in spite of the differences which exist. In its broad sense here used, *Trigona* has a meaning to entomologists and biologists generally which is lost if the genus is dismembered.

In view of the fact that *Nogueirapis* represents a natural group among *Trigona*, it is regarded here as a valid subgenus. Its affinities are discussed in a special section below.

THE SUBGENUS *NOGUEIRAPIS* Subgenus *Nogueirapis* Moure

Nogueirapis Moure, 1953, Ciencia e Cultura, S. Paulo, v. 5, No. 4, p. 247.

Type species: *Trigona butteli* Friese, 1900 (by original designation and monotype).

DIAGNOSTIC CHARACTERS The subgenus *Nogueirapis* can be easily

recognized from any other group of stingless bees by the combination of characters 2, 8, 10, 18 and 22 below. The characteristic black spot on the frons and vertex, plus the black distal area of the hind tibia can be used as an easy and quick way to separate them from other bees. Characters are:

1. Small to medium size (3 to 5 mm. in length).
2. Body ferruginous with dark markings which consist mainly of large bilobed area on upper part of head (Fig. 1), distal area of hind tibia (Fig. 2, A to C), hind basitarsus, and distal border of each abdominal tergum.
3. Cuticular surface smooth and polished with punctuation very sparse and delicate.
4. Anterior width of head 1.2 times anterior length.
5. Antennal sockets perceptibly below middle of face and immediately above epistomal suture, so that length of supra-antennal area is twice length of infra-antennal area.
6. Subantennal sutures absent.
7. Scape not reaching anterior ocella.
8. Interantennal space 1.7 times width of flagellum.
9. Lateral portions of epistomal suture almost straight and diverging anteriorly.
10. Width of clypeus about twice its length.
11. Length of malar space less than width of flagellum.
12. Preoccipital carina absent.
13. Mandibles bidentate on inner apical margin.
14. Length of pronotum twice width of flagellum.
15. Width of mesoscutum 1.1 times its length.
16. Mesoscutellum short but extending backwards slightly, just covering mesal portion of metanotum as seen from above, and with apex rounded.
17. Width of mesoscutellum about twice its length.
18. Distance between lower metapleural suture and second coxa less than width of flagellum.
19. Basal area of propodeum glabrous.
20. Hind tibia subtriangular to subclaviform, with posterior distal extremity rounded, at most slightly angular.
21. Corbicula occupying slightly more than half of tibia.
22. Posterior margin of hind tibia with simple hairs only.
23. Inner surface of hind tibia uniform, without a depression along the posterior border. (In *T. silacea* there is an apparently median elevation which seems to leave a posterior flange or depression; however, the apparent depression is differentiated only by its dark coloration and lack of hairs, and not by an actual elevation.)
24. Length of basitarsus about twice its width.
25. Sides of basitarsus subparallel, with posterior angle slightly projected.
26. Inner surfaces of basitarus uniformly covered with bristles.
27. Pterostigma relatively narrow, its length about four times its width.
28. Submarginal angle (between R_s and $R_s + M$) right angular to slightly more than 90° .
29. Hind wing with 5 hamuli.
30. Jugal lobe slightly less than one half as long as vannal lobe.
31. Abdomen relatively short and wide, subtriangular, with dorsal surface slightly convex.

DISTRIBUTION This subgenus is restricted to the American continent. *T. silacea* is found in Mexico; *T. mirandula* in Costa Rica and Gorgona Island, and *T. butteli* in Brasil, Perú and Bolivia.

AFFINITIES The exact position of *Nogueirapis* is still uncertain. Indications are that this subgenus is a primitive group. This is shown by its long geological history and by its unspecialized gen-

eral morphology. Unfortunately, the chromosome number, nest structure, and communication system are at present not known; such data would help to evaluate its level of primitiveness. On the basis of its unspecialized morphology and general appearance, the subgenus *Plebeia* appears close to *Nogueirapis*. However, *Plebeia* differs from it by the possession of a narrow depression along the posterior border of the inner surface of the hind tibia. The similarities of *Nogueirapis* and *Plebeia* are so striking that if the former had the narrow depression in the hind tibia there would be little hesitation by a bee specialist in placing the bees that we are now grouping as *Nogueirapis* in the subgenus *Plebeia*. Moure (1953) has placed great emphasis on the nature of the inner surface of the hind tibia, and has distributed phylogenetically all the stingless bees in three major groups: (1) bees which have the inner surface of the hind tibia normal, without any type of depression, (2) bees with a narrow depression along the posterior border of the inner surface of the hind tibia, and (3) bees with a wide depression along posterior area of the inner surface of the hind tibia which widens at its apex. Since the hind tibia of most stingless bees has another small depression or face along the anterior region of the tibia, the bees of this third group appear to have a median elevation along the whole length of the tibia. Since *Nogueirapis* belongs to the first group and *Plebeia* to the second one, Moure has not placed *Nogueirapis* close to *Plebeia*, in spite of the fact that they are similar in other respects. Therefore, *Nogueirapis* has been placed among the bees of group 1. Unfortunately, most bees of this group (*Partamona*, *Paratrigona*, *Scaptotrigona*, and *Nannotrigona*) are, in spite of the unspecialized inner surfaces of the hind tibia, highly specialized in many other respects. *Partamona*, however, is less specialized than *Paratrigona*, *Scaptotrigona*, and *Nannotrigona*. This is the reason why Moure has placed *Nogueirapis* close to *Partamona*, as a subgenus of it. But since there are some important differences between *Nogueirapis* and *Partamona*, there seems little justification for placing them together. *Partamona* differs from *Nogueirapis* mainly in the epistomal suture, the lateral portions of which are subparallel over their basal halves or more and then diverge abruptly in apical halves; in the propodeum, in which the basal area is covered with hairs; in the hind tibia, which is spoon-shaped; in

the corbicula, which is large; and in the malar space, which is larger. All these characters are presumably specializations, not found in *Nogueirapis*. But if we accept the nature of the inner surface of the hind tibia as one of the main phylogenetic trends in the stingless bees, then the group *Nogueirapis* is at the very bottom of the series of bees with normal inner surfaces of hind tibiae. Similarly *Plebeia* seems to be at the bottom of the series of bees with a narrow depression along the posterior border of the hind tibia. This situation may explain why *Plebeia* and *Nogueirapis* are morphologically similar, even if they are not in the same line of evolution.

Key to the species of *Nogueirapis*

1. Fossil; length of body 3 mm.; base of first median cell petiolated
silacea Wille
- Living length of body 5 mm.; base of first median cell non-petiolated ... 2
2. Mesoscutum black; rastellum composed of 8 strong bristles
mirandula Cockerell
- Mesoscutum ferruginous; rastellum composed of 9 strong bristles
butteli Friese

Trigona (Nogueirapis) silacea Wille

Trigona (Nogueirapis) Silacea Wille, 1959, Journal of Paleontology 33, No. 5, p. 849.

SIZE Length 3 mm.; length of forewing 2.7 mm.

COLOR General color ocher or ferruginous. A large bilobed dark spot on upper part of head (Fig. 1, A), covering vertex and extending anteriorly about two thirds of supra-antennal area, to level above antenna, where black is excavated medially around frontal line, excavation narrow and more or less triangular in shape, not reaching anterior ocellus, separated from it by a width which is slightly more than twice width of flagellum; lower ends of spot gently curved and at sides gradually curved upwards leaving narrow ocher paraocular area; posteriorly, black spot extends to same level as anteriorly. Other dark areas: dorsal surface of flagellum; distal margin of mandible and narrow strip at base; malar area; scutellum, metanotum, inner and outer sides of posterior (one fourth) and distal (one sixth) border of hind tibia (Fig. 2, A); hind basitarsus; distal border of each abdominal tergum, thus forming a series of five (the sixth slightly indicated) black bands, each band as wide as width of flagellum.

STRUCTURE Length of eye 2.2 (2.3) times breadth; length of malar space slightly less than (.85) width of flagellum; anterior border of pronotum slightly concave; distance between lower metapleural suture and second coxa one third width of flagellum; length of propodeal spiracle 3.3 times its width; shape of hind tibia subtriangular (Fig. 2, A), with posterior distal angle rounded; length of hind tibia 2.5 times its width; without well

defined corbicular hairs (long hairs found sometimes on the corbicular surface), rastellum composed of 10 to 14 long hairs slightly longer than width of flagellum; hairs of inner surface of hind tibia confined to median region, leaving posteriorly a wide glabrous margin (almost as wide as flagellar width); forewing with following veins usually weakly indicated: Cu, Cu₁, Cu₂, 1st m-cu, and following abscissae of M; submarginal cells virtually absent; but sometimes weakly indicated; length of marginal cell 3.6 times its width; submarginal angle (basal angle first R₁ cell) about 90°; base of first median cell petiolated (Fig. 2, D).

VARIATION There are some variations in the color of the fossil forms. Some of these differences are obviously due to the direction of light in the amber. Thus, the dark areas may appear either black or brown.

Other minor morphological variations can be attributed to the medium of

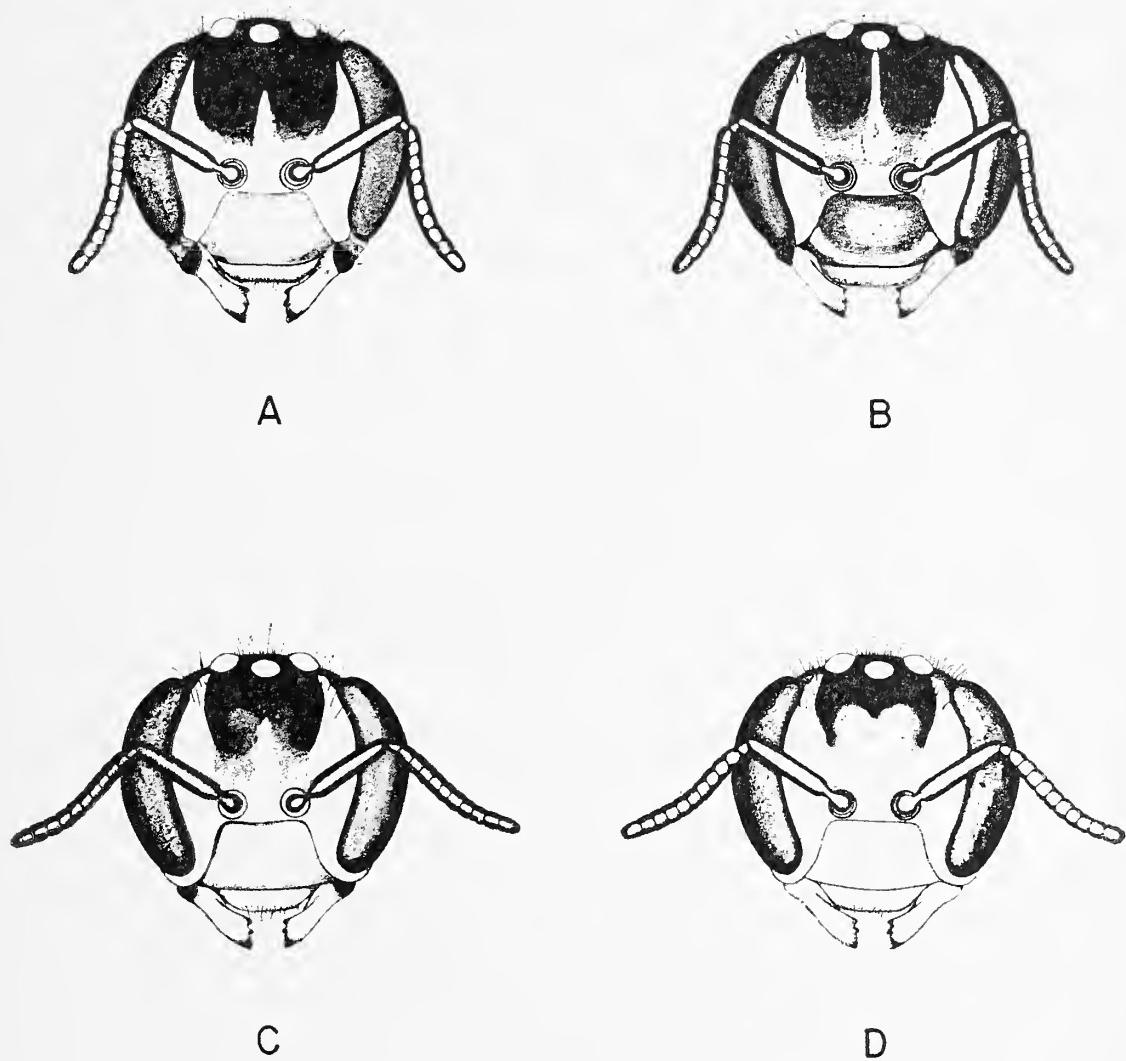


FIG. I

FIG. 1. Anterior view of head of: A. *Trigona silacea*; B. *Trigona mirandula*; C. *Trigona butteli* (a variant); D. *Trigona butteli*.

preservation, for example, the small variations in the relative lengths of some of the structures may be due to the different pressures exerted by the amber on some of the specimens.

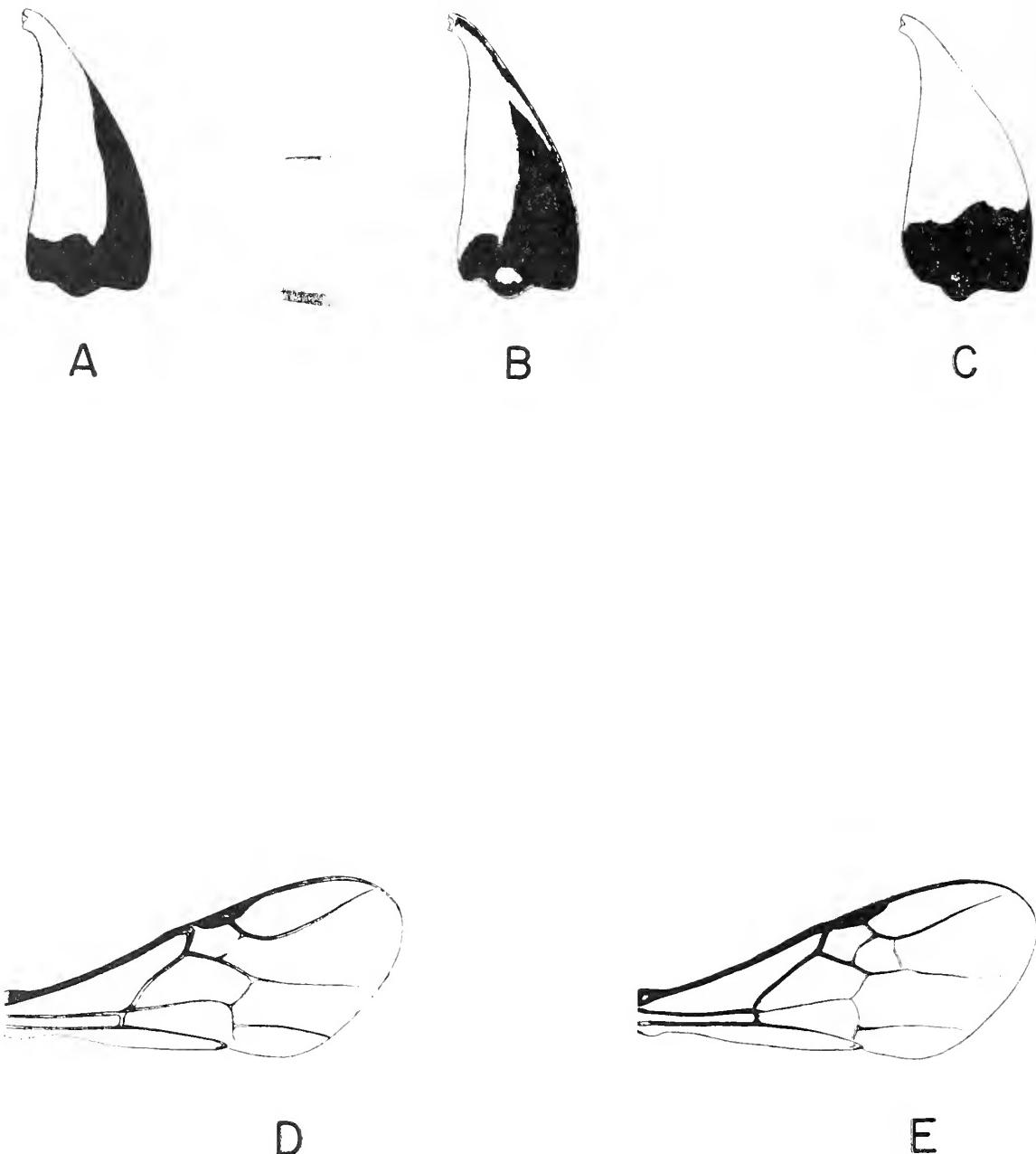


FIG. 2

FIG. 2. Outer surface of left hind tibia and left forewings of *Nogueirapis* (hairs omitted). A. *Trigona silacea*; B. *Trigona mirandula*; C. *Trigona butteli*; D. *Trigona silacea*; E. *Trigona mirandula*.

DISTRIBUTION All the specimens known come from Chiapas, Mexico, from two different localities in the vicinity of Simojovel: from Rio San Pedro, opposite town of San Pedro and from the Simojovel landslide.

TYPE MATERIAL the holotype No. 12601, and paratypes Nos. 12602-12611 are in the Museum of Paleontology, University of California.

SPECIMENS EXAMINED Besides the holotype and paratypes the author has examined a large new series of specimens found recently by the University of California, from the same area.

Trigona (Nogueirapis) mirandula Cockerell

Trigona mirandula Cockerell, 1917, Psyche, 24, No. 4, p. 122.

SIZE Length 5 mm.; length of forewing 4.6 mm.

COLOR General color ferruginous; distal border of mandible reddish. A large bilobed black spot on upper part of head (Fig. 1, B), covering vertex and extending anteriorly about two thirds of supra-antennal area, to level above antenna, where black is excavated medially around frontal line, excavation narrow, half width of flagellum, and reaching anterior ocellus, but sometimes separated from it by a width equal to that of flagellum, lower ends of spot gently curved and at sides curves upwards and toward eye margin at summit, leaving a wide yellowish paraocular area, much wider than width of flagellum; posteriorly, black spot extends only near upper margin of declivity of posterior surface of head. Other dark or black areas: dorsal distal part of scape; pedicel; flagellum dark brown, slightly paler beneath; around posterior articulation of mandible; mesoscutum; scutellar crest; outer surface of posterior (half) and distal (one fifth) border of hind tibia (Fig. 2, B); outer surface of basitarsus; tarsus almost black; distal border of each abdominal tergum, thus forming a series of five (the sixth slightly indicated) black bands, each band much wider (1.5) than width of flagellum. When the abdomen is contracted, each basal portion of tergum, which is dark ferruginous, is covered by the black distal border of the preceding segment; therefore, the dorsal surface of abdomen may appear as black. The following parts yellowish: paraocular areas; a bottle-shaped area around frontal line, but with a small ferruginous line medially in the wider portion; inter-antennal area, just above clypeus; a very narrow area in anterior portion of clypeus, slightly wider at both extremities (sometimes only the extremities are evident as two yellowish spots); basal half of mandible; scape, except black portion, although sometimes it approaches ferruginous; a narrow genal area along posterior margin of eye; a narrow band along lateral margins of mesoscutum; axillae; basal half or pronotum; posterior lobe of pronotum and metaepisternum appear paler in color, almost ferruginous; wings of a uniform yellowish gray color.

STRUCTURE Length of eye 2.5 times breadth; length of malar space slightly less than half (.35) width of flagellum; anterior border of pronotum slightly

concave, almost straight; distance between lower metapleural suture and second coxa one fourth width of flagellum; length of propodeal spiracle 3.8 times its width (measure from inner border of atrial rim); shape of hind tibia subtriangular (Fig. 2, B) with posterior distal extremity slightly angulated; length of hind tibia 2.5 times its width; with a corbicula hair, almost as long as length of scape (there is another long hair, but much shorter than corbicula hair and closer to hind border of tibia); rastellum composed of 8 strong bristles, as long as width of flagellum, and restricted to median area of distal border of tibia; hairs of inner surface of hind tibia uniformly distributed posteriorly, leaving just a very narrow margin glabrous; vein separating first and second submarginal cells (Rs) relatively well indicated, that separating second and third (1 r-m) virtually absent; length of marginal cell 3.8 times its width; submarginal angle (basal angle of first R_1 cell) a right angle; base of first median cell non-petiolated (with vein separating first cubital and median cells transversally placed. Fig. 2, E). VARIATION The main variation found is in the length of the narrow yellowish strip around the frontal line, which usually reaches the anterior ocellus. In some of the specimens, however, the strip does not extend as far as the anterior ocellus, and can be separated from it by a width equal to that of flagellum (Fig. 3, B).

DISTRIBUTION As far as we know this species occurs only in Costa Rica, in a place called Pozo Azul de Acosta, and in Gorgona Island, Colombia. The type locality is Pozo Azul. This place, with an altitude of 82 to 200 meters, is located in the pocket-like area formed by the union of the rivers Rio Grande Candelaria and Rio Pirrís (Parrita). The area is isolated toward the west, south and east by the two rivers, and toward the north by the high mountains of Sabanillas de Acosta (1165 m.) and Serros del Dragón (2505 m.). This species was collected for the first time in June 15, 1909 by M. A. Carriker. During the following 52 years it was not collected again in Costa Rica. Very recently, however, the author has secured a large series of *T. mirandula* during three expeditions to Pozo Azul. So far, the author has failed to collect this bee from any place other than Pozo Azul.¹

The existence of *T. mirandula* in the island of Gorgona, at present a penal colony, was observed by Moure when studying Chessman's material in the British Museum. According to Moure, in a personal communication, what Chessman (1929) calls *Trigona mosquito* var. *variicolor* from Gorgona Island is

¹ However, since this paper was submitted for publication, I have collected *T. mirandula* in Rio Damitas, 14.5 Kms. north of Quepos, at the base of the mountains of Dota (altitude 200 m.), province of San José, Costa Rica.

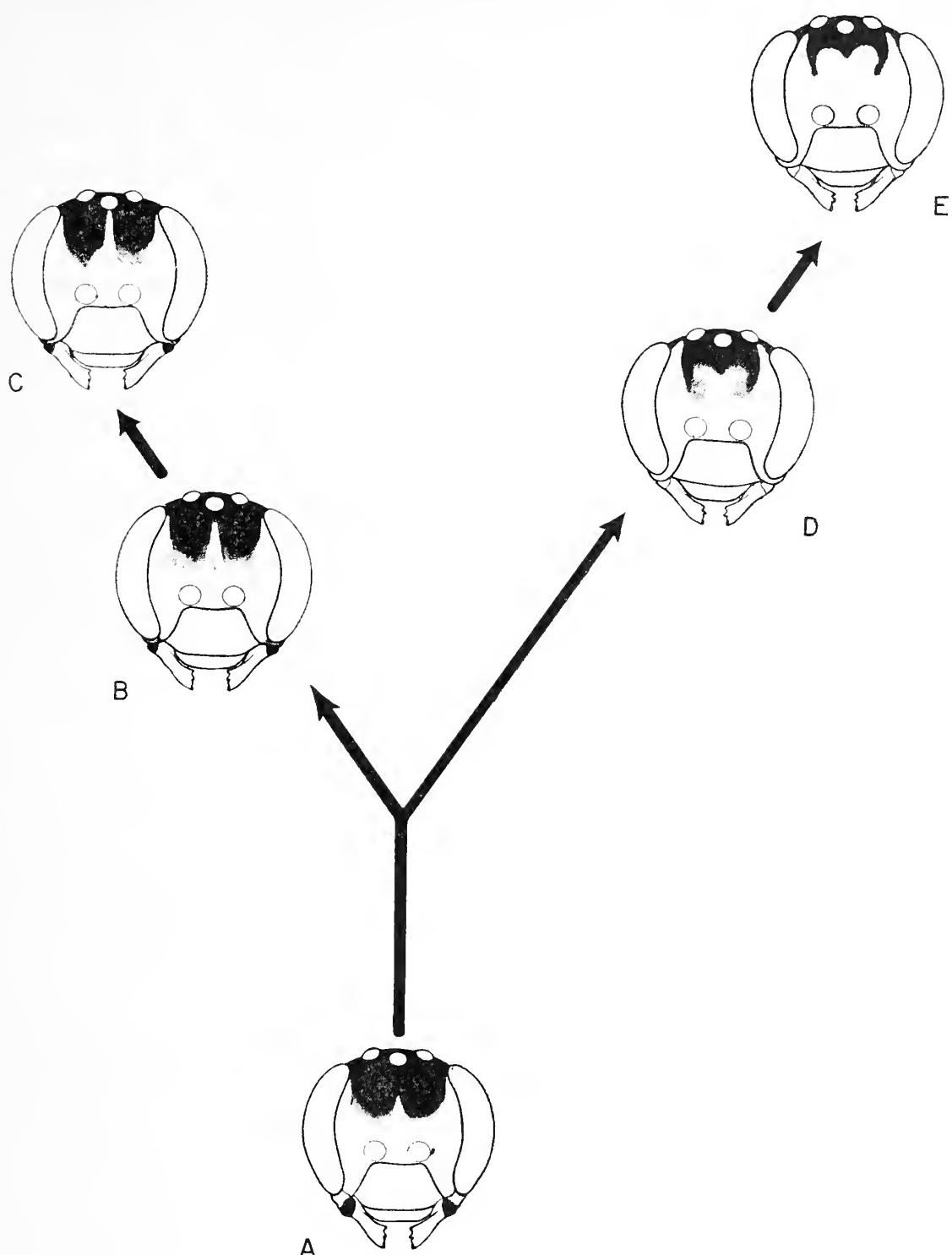


FIG. 3

FIG. 3. Evolutionary trends of the black spot on the frons and vertex in *Nogueirapis*. A. As in *Trigona silacea*. B. As in *Trigona mirandula* (a variant). C. As in *Trigona mirandula*. D. As in *Trigona butteli* (a variant). E. As in *Trigona butteli*.

actually *T. mirandula*, which differs from the type only in very minor things. Since the type of *variicolor* exists, the name *mosquito* var. *variicolor* applied to the bee from Gorgona Island is a misidentification and not a synonym of *mirandula*.

BIOLOGICAL DATA Practically nothing is known about the biology of this bee. There is hope that soon the author may be able to carry out some research on its general behavior. The species seems to be strictly a jungle form, not a single specimen has been collected in flowers outside of the forest, not even in areas close to the edge of the jungle. Workers are easily attracted with a solution of honey. The first time they were collected by the author, they were on a fallen tree, where some woody vines had stripped and torn the bark, the bees being attracted to the sap of the wounds.

TYPE MATERIAL The holotype No. USNM-23168 is in the U. S. National Museum. A plesiotype worker from Pozo Azul, Costa Rica, is here designated and is being sent to the Snow Entomological Museum at the University of Kansas.

SPECIMENS EXAMINED Besides the plesiotype, the redescription has been based on 50 specimens, all from Pozo Azul, Costa Rica.

Trigona (Nogueirapis) butteli Friese

Trigona butteli Friese, 1900, Természetrajzi Füzetek, 23, p. 393.

Melipona butteli, Ducke, 1916, Revisão das Espécies de Abelhas do Brasil, in Comissão de Linhas Telegraphicas Estratégicas de Matto Grosso ao Amazonas, (Publicação No. 35), Anexo No. 5, Historia Natural, Zoologia, p. 33; Ducke, 1916, l.c., p. 100; Ducke, 1925, Zool. Jahrb., Abt. Syst., vol. 49, p. 398.

SIZE Length 5 mm.; length of forewing 4.6 mm.

COLOR General color pale ferruginous; distal border of mandible reddish. A large black spot on upper part of head around ocelli (Fig. 1, C), extending anteriorly about one half of supra antennal area, where it gradually fades away to brown and pale brown color down to level of antennae, but leaving uncovered a pale ferruginous to yellowish area around base of frontal line, and a wide pale yellowish paraocular area, much wider than width of flagellum. Anteriorly, dark spot fades away unevenly, thus lateral sides of dark area extend down more than general median region, forming two lateral projections (Fig. 1, C); there is also a smaller V-shaped projection along frontal line sometimes weakly indicated. Area between posterior ocelli and eye margin dark brown, that behind it very light brown. Other dark areas: dorsal part of scape; pedicel; dorsal part of flagellum; anterior part of mesoscutum slightly darker; outer surface of distal third of hind tibia (Fig. 2, C); outer surface of basitarsus; distal border of each abdominal tergum, thus forming a series of five (the sixth slightly indicated)

black bands, each band as wide as width of flagellum. The following parts pale yellowish: paraocular areas; around frontal line; interantennal area; most of clypeus, slightly darker at its sides and more yellowish at distal extremities; basal two thirds of mandible; scape, except black portion (occasionally ferruginous); a narrow genal area along posterior margin of eye, sometimes not well indicated; a narrow band along lateral margin of mesoscutum; axillae; basal half of pronotum; wings of a uniform yellowish gray color.

STRUCTURE Length of eye 2.2 times breadth; length of malar space slightly more than half (.62) width of flagellum; anterior border of pronotum slightly concave; distance between lower metapleural suture and second coxa one half width of flagellum; length of propodeal spiracle 3.8 times its width (measure from inner border of atrial rim); shape of hind tibia subelaviform (Fig. 2, C) with posterior distal extremity slightly angulated; length of hind tibia 2.4 times its width; with two corbiculate hairs, sometimes only one, almost as long as length of scape; rastellum composed of 9 strong bristles, as long as width of flagellum, and restricted to median area of distal border of tibia; hairs of inner surface of hind tibia uniformly distributed posteriorly, leaving just a very narrow margin glabrous; vein separating first and second submarginal cells (Rs) faintly indicated, that separating second and third virtually absent; length of marginal cell four times its width, submarginal angle (basal angle of first R_1 cell) slightly more than 90° ; base of first median cell non-petiolated (with vein separating first cubital and median cells transversally placed).

VARIATION The main variation found is in the dark spot on the upper part of head, which may appear with the two lateral projections larger, and resembling more the bilobed condition (Fig. 3, D).

DISTRIBUTION The species was originally described from Vilcanota, Departamento Cuzco, Perú. It was collected later in Pebas, Departamento Loreto, Perú; in Tarata, Departamento Cochabamba, Bolivia, and Tefé, Estado de Amazonas, Brasil. More recently (1952) it has been collected by Theodore Dobzhansky in the mouth of the river Vaupés (Caiarí), Territory of Rio Negro, Brasil.

BIOLOGICAL DATA none

TYPE MATERIAL According to Moure (personal communication) the holotype should be in Friese's collection in the Zoologischen Sammlungen in the Humboldt Universität. Moure saw a "cotypus" from Pebas, Perú, labeled as "typhus" by Friese, in the American Museum of Natural History in New York. A plesiotype worker from the mouth of the river Caiarí (Terr. Rio Negro), Brasil, is here designated and returned to the Snow Entomological Museum at the University of Kansas.

SPECIMENS EXAMINED Besides the pleiotypic from Brasil, the re-

description has been based on one specimen from Tarata, Bolivia, and another one labeled simply "Perú, 1900," possibly from Vilcanota.

DIFFERENCES AMONG THE THREE SPECIES OF *NOGUEIRAPIS*

The two living forms, *T. mirandula* and *T. butteli*, are closely related species. Not only are they morphologically similar, but the color and general distribution of the dark and yellow marks are almost identical. A comparison between the two species gives the general impression that the color of *T. butteli* is slightly more faded. The obvious difference is the color of the mesoscutum, which is black in *T. mirandula* and ferruginous in *T. butteli*. The other color differences are minor details, all of which are summarized in Table I.

The main morphological differences between the two living forms are found in the proportions of the eye and in certain details of the hind tibia. In *T. mirandula* the compound eye is slightly narrower and larger than that of *T. butteli*; consequently, the malar space is very small in *T. mirandula* and slightly larger in *T. butteli*. The hind tibia is slightly wider in the South American form than in the Costa Rican species, and tends to be subclaviform rather than subtriangular as in *T. mirandula*. There is one well developed corbicula hair in *T. mirandula*, while there are usually two in *T. butteli*. Moreover, the latter species has a rastellum formed by 9 strong bristles, while in *T. mirandula* the rastellum is formed by 8 strong bristles. These morphological differences as well as the minor ones are summarized in Table I.

Although the two living species are similar to the fossil form, there is a larger gap between it and the living forms than between the two living species. These differences are mainly in size, a character in the wing venation and some details of the hind tibia. As to the color, there are minor differences, although nothing is known about the possible yellow marking in the fossil, since the amber would not allow the distinction of such a color.

Of the two living species, *T. mirandula* is more closely related to the fossil form. This is shown in Table I, in which the general color, the anterior view of the black spot on the top of the head, (Fig 1, A, B), the color of the posterior articulation of the mandible, the color of malar space, the distribution of the black color on the hind tibia (Fig. 2, A, B), the shape of the hind tibia

(Fig. 2, A, B), and the submarginal angle of the forewing, are characters which agree in *T. silacea* and *T. mirandula*.

TABLE I

Color and Morphological Differences Among the Three Species of *Nogueirapis*

Characters	<i>T. silacea</i> (fossil)	<i>T. mirandula</i>	<i>T. butteli</i>
General color	ferruginous	ferruginous	slightly pale ferruginous
Yellow markings	Probably present, well defined but not visible in amber		poorly defined
Anterior view of black spot on top of head	bilobed	bilobed	bilobed condition not well defined
Posterior view of black spot on top of head	Extending down to same level as anteriorly	extending only near upper margin of declivity of posterior surface of head	does not extend beyond ocellar area
Color of posterior articulation of mandible	brown to black	black	pale
Color of malar space	dark	dark	pale
Color of mesoscutum	ferruginous	black	ferruginous
Color of scutellum and metanotum	dark	ferruginous, with pale ferruginous scutellar crest darker	
Distribution of black color on hind tibia	posterior (one fourth) and distal (one sixth) borders	posterior (one-half) and distal (one fifth) borders	distal (one third) border
Color of basal area of each abdominal tergum	ferruginous	dark ferruginous	ferruginous
Length of body	3 mm.	5 mm.	5 mm.
Proportions of eye	Length 2.2 (2.3) times breadth	length 2.5 times breadth	length 2.2 times breadth
Malar space	slightly less than (.85) width of flagellum	slightly less than half (.35) width of flagellum	slightly more than half (.62) width of flagellum
Distance between lower metapleural suture and second coxa	$\frac{1}{3}$ width of flagellum	$\frac{1}{4}$ width of flagellum	$\frac{1}{2}$ width of flagellum
Shape of hind tibia	subtriangular	subtriangular	subclaviform
Length of hind tibia	2.5 times its width	2.5 times its width	2.4 times its width
Restellum	10 to 14 long hairs	8 strong bristles	9 strong bristles
Corbicicular hairs	without well defined corbicicular hairs	with one corbicicular hair	with two corbicular hairs (some times with only one)

TABLE I (continued)

Color and Morphological Differences among the Three Species of *Nogueirapis*

Characters	<i>T. silacea</i> (fossil)	<i>T. mirandula</i>	<i>T. butteli</i>
Hairs of the inner surface of the hind tibia	confined to median region leaving a wide glabrous margin posteriorly (almost as wide as flagellar width)	hairs uniformly distributed posteriorly, leaving just a very narrow margin glabrous	hairs uniformly distributed posteriorly, leaving just a very narrow margin glabrous
Submarginal angle	right angle	right angle	slightly more than 90°
Base of first median cell	petiolated	non-petiolated	non-petiolated

POSSIBLE EVOLUTION OF THE SUBGENUS *NOGUEIRAPIS*

The similarity of the two living species to the fossil form suggests that *T. mirandula* and *T. butteli* are survivors of a line of descent from *T. silacea* (Fig. 3). On the other hand, the differences between the fossil form and the two living species indicate the existence, possibly only in the past, of intermediary forms. It is conceivable that all three species are mere branches from a form or from even different closely related species. The existence of the fossil in Mexico, the geographical distribution, and the more or less intermediate position of *T. mirandula*, seem to suggest that the subgenus *Nogueirapis* originated north of Central America, possibly during the Oligocene, when most of Central America was under water. The migration of *Nogueirapis* toward the south was therefore almost impossible up to the Pliocene, when Central America was again a connecting bridge between North and South America. The Oligocene was actually the ideal geological epoch for the stingless bees to evolve. The warm and humid climate and the world-wide distribution of tropical forests during the Oligocene undoubtedly favored their adaptive radiation. However, the stingless bees as a group probably originated during the Eocene, when modernization of flowering plants and development of extensive forests took place. During the Oligocene, Miocene and Pliocene, *Nogueirapis* probably evolved into several species. The first ones were probably small bees, the size of *T. silacea*. Others may have evolved later, in which the capacity for collecting pollen improved. This im-

provement was reflected in the increase of size (corbicular surface), a well developed rastellum, made up of stiff setae, and the appearance of corbicular hairs, which possibly help in holding together the mass of pollen on the corbicula. During the Miocene the species of *Nogueirapis* were probably impelled to migrate south, since the climate in North America started to change greatly, becoming cool and semi-arid. It was also the beginning of forest reduction. In the Upper Miocene Costa Rica emerged again, establishing a connection with Nicaragua, and forming a bridge that could be used by the migrating bees. During the Pliocene the climate continued to grow cooler, with increasing restriction of forests, and the Central American bridge was well formed. Possibly by this time *T. mirandula* was well established throughout Central America, and the migration of the species of *Nogueirapis* continued into South America, where *T. butteli* became well established over much of the continent. The continued coolness of climate and the periodic glaciation during the Pleistocene may have been some of the causes for the extinction of great mammals and many trees, and probably also of several species of *Nogueirapis*, leaving *T. mirandula* and *T. butteli* as the only known survivors of the subgenus.

ACKNOWLEDGMENTS

I am indebted to Dr. C. D. Michener of the University of Kansas and Dr. Rafael Lucas Rodríguez of the University of Costa Rica, for reading the manuscript and offering suggestions. I am also grateful to P. D. Hurd of the University of California, for making the fossil material available for study. Also Dr. C. D. Michener kindly sent specimens from the Snow Entomological Museum and Pe. J. Moure provided data on the type material. Mr. William Ramíre and Mr. Guillermo Ulate helped to collect specimens of *T. mirandula*.

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Taxonomists—Please note

Genus *Zimmeria* Ruckes preoccupied
(Heteroptera : Pentatomidae)

In 1958 (Amer. Mus. Novitates, no. 168, p. 20) I erected the genus *Zimmeria* to receive three species of halyine pentatomids, viz. *vivanai* (Kormilev), *stali* (Kormilev), and *bergi* (Kormilev). I have since discovered that this generic name is preoccupied by *Zimmeria* Heinrich 1933 (Mitt. Zool. Mus. Berlin, 19, p. 159) for a species in the Ichneumoninae Hymenoptera. It is therefore necessary that the name *Zimmeria* Ruckes be changed. Since I used this name in honor of my good friend the late Dr. John T. Zimmer, I wish to retain the basic part of it and therefore propose the use of *Zimmerana* in its place.

Herbert Ruckes
American Museum of Natural History

A NEW SPECIES OF THE GENUS *OXAEA* FROM BRAZIL (HYMENOPTERA: APIDAE)¹

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ABSTRACT

O. schwarzii n.sp. is described. This species has the mandible broadly expanded and obliquely truncated at its apex and it is provided with a basal, inner tooth. The tegument of the abdominal terga is entirely black and here in the males the green metallic luster is almost completely lacking in the marginal depressions.

Oxaea and *Protoxaea* are two genera of large Andrenide bees placed by Michener (1944) in the subfamily Oxaeinae. Apparently their close relatives are the species of the Old World genus *Melitturga* which constitutes the only genus of the tribe Melitturgini of the Panurginae.

Protoxaea is easily recognized by the possession of the long six-segmented maxillary palpi. The genus includes about seven species flying from Mexico to the southern United States, and one representative in South America, *Protoxaea ferruginea* (Friese, 1898), known from Mendoza, Argentina, to southern Mato Grosso, Brazil. The synonymy of this species has been recently revised by the senior author (1947).

The genus *Oxaea*, confined to the Guiano-Brazilian subregion, lacks the maxillary palpi. The females have green metallic abdominal terga, but this color is confined to the marginal depression of the terga in males. In the present species the tegument is entirely black with the green metallic luster almost completely lacking on the marginal depressions.

The strong convergence of the inner orbits towards the vertex is suggestive of *O. festiva* and *O. stenocoryphe*, but on the other hand *O. schwarzii* is unusual in that the mandibles are broadly

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expanded and obliquely truncate at the apex and provided with a basal inner tooth.

Oxaea schwarzii new species

MALE Black, with some steel-bluish reflections on terga except for the marginal depressions which have a metallic black brilliance with a very weak green reflection on certain light; second to fourth tarsal joints more or less reddened. Wings moderately fuscous especially towards the marginal and submarginal cells; tegulae and venation black.

Pubescence dark fuscous on vertex, thorax, legs, propodeum and both sides dorsal and ventral of the abdomen; pale whitish on frons, lower half of the face and lower four-fifths of the genae. Posterior disc of mesoscutum and the two elevated areas of scutellum glabrous. Lateral tufts of metasomal terga moderately developed, on terga 5-7 of similar character but longer and denser with a tendency to cover more of the basal region.

Punctuation rather close and fine on frons, with some traces of impunctate areas on parocular and median regions; a small triangular area on the lower part of the supraclypeus densely but finely tessellated with two or three irregular punctures; clypeus covered with dense but clearly separated punctures on sides, on central part with scattered punctures forming a wide line broadened below, dull and tessellated. The punctures of thorax slightly finer than those on vertex, rather dense forward and latrad; mesoscutal disc and elevated areas of scutellum sparsely punctured with shiny spaces between the punctures about two to four diameters of puncture; metanotum with fairly sparser but coarser punctures leaving a median impunctate area. Upper half of the mesepisterna with crowded but distinct punctures, the lower half with sparser punctuation; on the basal area of the propodeum a little coarser and sparser than on the metanotum and sparser mesad, on the other areas of the propodeum finer and denser. The basal part of the terga covered with small, distinct and moderately dense punctures but clearly separated and sparser mesad, more emphatically so on third and fourth terga; the marginal depression of terga 1-6 smooth with a sericeous luster; these depressions progressively wider toward the apex, the first one as broad as a little less than the maximum diameter of the flagellum, the fifth depression more than twice as broad as the first.

The head slightly broader than long, but narrower than thorax; inner orbits almost straight, strongly converging above, the lower interorbital distance shorter than eye length but about four times as long as the upper interorbital distance (185: 32: 122). Malar area short, the shortest distance from the eye to the mandible distinctly shorter than the smaller diameter of the basal joint of the flagellum. The mandible expanded and laminated distally, its apex obliquely truncate and with a strong rounded basal tooth on inner border. The clypeus strongly protuberant, its length about two-thirds of its width, more than twice as long as the clypeocellar distance (71: 115: 31). The interalveolar distance more than twice as long as the diameter of the alveolus, but three times as long as the alveolorbital distance; the latter a trifle longer than the distance between the upper border of the alveolus and

the lower tangent of the lateral ocelli (38: 13: 12: diameter 15). The ocelli very low on the frons, the distance between the upper tangent of the median ocellus and the upper part of the vertex longer than twice the upper interorbital distance (80: 32); the interocellar distance a little longer than the transverse diameter of the median ocellus, but more than three times as long as the ocellorbital distance (25: 7: diameter 19). The scape of the antenna equal to the interalveolar distance, much shorter than the basal segment of the flagellum, but longer than the following four flagellar segments together (38: 46: 7: 12: 9: 11.5: diameter of the fourth flagellar segment 12).

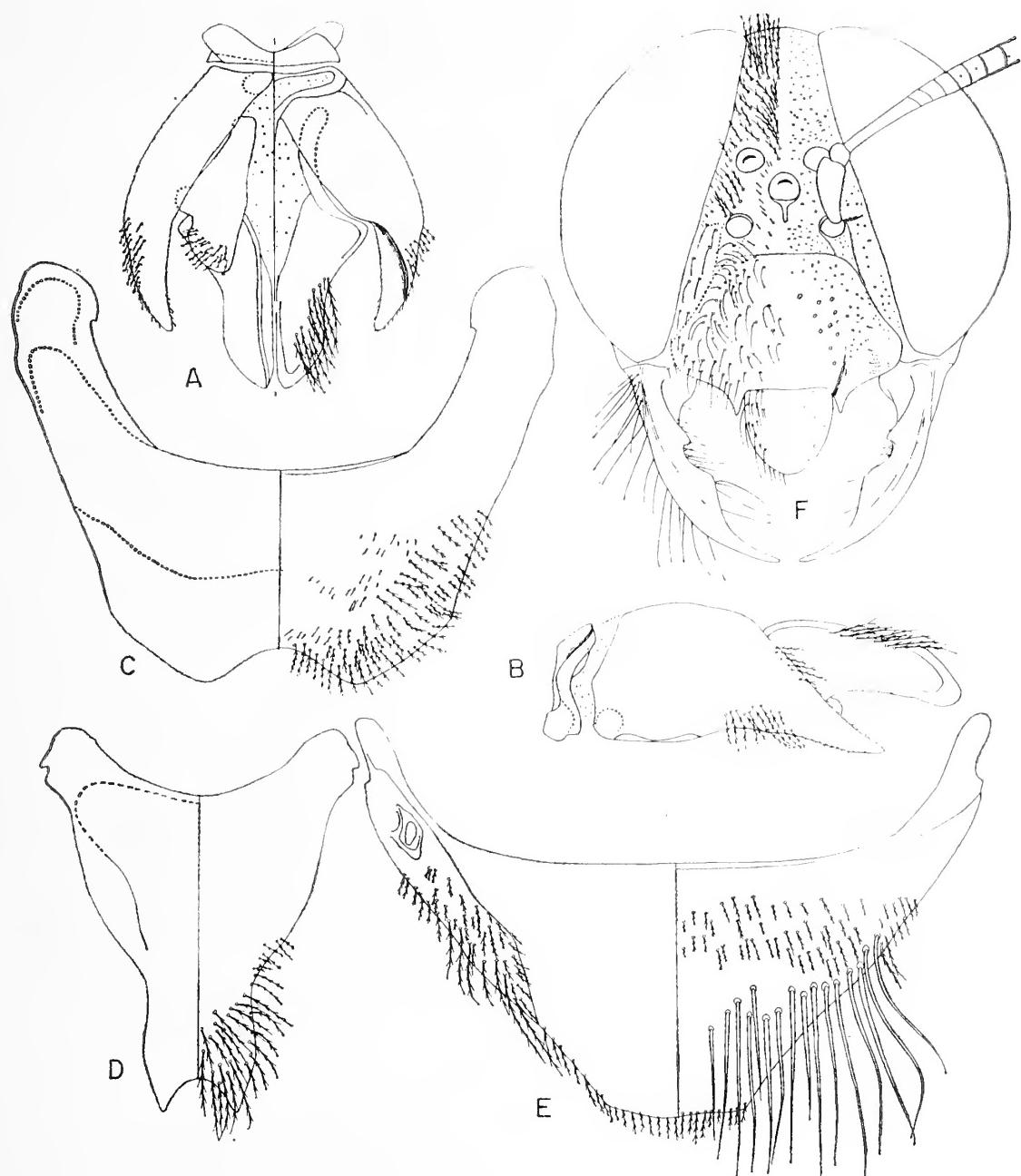


Fig. 1 *Oxaea schwarzii*. Male head (F) and terminalia: seventh tergum (E) (left half ventral), seventh (C) and eighth (D) sterna (left halves dorsal), and genitalia (A) (left half ventral) and (B) (lateral).

SIZE Length 17.5 mm, wing 15.5 mm; breadth of head 5.7 mm of thorax (between outer borders of tegulae) 7.8 mm and of abdomen 7.6 mm.

HOLOTYPE Male in Moure's collection, one male paratype in Campos Seabra's collection.

TYPE LOCALITY Vitória da Conquista, BA-BRAZIL, 21-25-V-1961, F. M. Oliveira leg.

Communication

A letter received from Dr. J. Moure (senior author of the preceding paper) states that he has already named two Meliponine bees in honor of the late Herbert F. Schwarz. *Schwarziana* was designated in 1943 and *Schwarzula* was designated in 1946 as "a modest homage to so distinguished an entomologist and it is a pleasure to collaborate in this special issue of your Journal."

THE SCUTELLUM NEST STRUCTURE OF *TRIGONA* (*TRIGONA*) *SPINIPES* FAB. (HYMENOPTERA: APIDAE)

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ABSTRACT

T. (T.) spinipes (= *ruficrus*) is a neotropical stingless bee living in Brasil, Paraguay and part of Argentina (Misiones). It builds an external nest, upon branches of trees.

Inside the nest there is a huge and massive structure, basin or shield-like in shape, the scutellum. It is made chiefly of prepupal dejections and adult bee excrements. It also contains dead bees, cerumen, propolis, Acarina, remains of brood cocoons, etc.

Besides other lesser roles, it is here suggested that the scutellum serves chiefly as a strong supporting wall for the nest's internal constructions. The author thinks that the presence of a strong wall of some sort—preexistent or bee made—is characteristic of all Meliponinae nests.

INTRODUCTION AND LITERATURE

Trigona (Trigona) spinipes Fab, commonly known as Irapuá or Arapuá, is a stingless bee found in large areas of Brazil, where it ranges from the State of Ceará to the State of Rio Grande do Sul. It exists also in Paraguay and Misiones Province, Argentina. On its geographical distribution see Schwarz (1948: 271).

Most authors, including Schwarz, called it *T. ruficrus* Latreille. However, Moure (1960: 155) examined a Fabricius type in the Zoologiske Museum, Copenhagen, and arrived at the conclusion that *spinipes* is the correct name.

This bee builds external nests, on branches of trees, first described by Seabra (1799: 104). It is also well known because of its habit of cutting flowers, leaves, bark, etc, for building material or for easier access to nectaries of some flowers. For a discussion of its destructive and nesting habits, see Schwarz (1948: 267–270).

As Seabra (1799: 101), F. Muller (apud H. Muller 1875: 43), Peckolt (1894: 223–225), H. von Ihering (1903 (1930: 77–78)), and other authors state, this is a vicious bee, biting an intruder

fiercely and in great numbers. A single bee is sufficient to annoy. Even when the observer wears a protective net over his face, an attack of hundreds of these bees is almost unbearable.

Inside the nests of this species there is a huge and massive structure, first described by H. von Ihering in 1903 (1930: 66-70, 81), who gave it the name of scutellum.

Silvestri (1904: 136), Mariano Filho (1910: 18-21; 1911: 127-128), Bertoni (1912: 142), and Ducke (apud Schwarz 1948: 268) also wrote briefly about this structure. Schwarz (1948: 25, 268, pl. 6) summarized the knowledge existing concerning the scutellum.

R. von Ihering (1940: 403) said that in Northeastern Brazil, in the São Francisco valley, this "compact part of the nest" is used in fishing. It is triturated, cooked and placed inside baskets, that are put in the water. It is extremely toxic to fish. Sawaya and Aguiar (1960: 93-94) wrote that the material they examined had a high content of acetylcholine, which they believed to be one of the fish killing substances present.

The study of the origin of the scutellum may reveal a better understanding of its properties as a fish poison.

Among other species of bees the scutellum is not definitely known altho the same structure may exist in the nests *T. (T.) corvina* and, in a different form, in the nests of *T. (T.) amalthea*. On *amalthea* there are short nest descriptions made by Bertoni (1912: 142), Salt (1929: 438), Myers (1935: 132), and Weyrauch (1942: 63-64). Michener (1946: 193-194) wrote more extensively on a nest of *corvina*.

MATERIALS AND METHODS

Nests A and E were from São Paulo city, State of S. Paulo, Brasil. The other nests were found in Cosmópolis, in the same State.

In order to observe the nests of this fierce bee, a variety of head masks, made of nylon and plastic were used. A lightly tied piece of wire over my coat sleeves was also used in order to stop the bees from crawling under my clothes. However, *spinipes* is not a large bee, and always gets inside the clothing and torments the observer. It was easy to examine nests on cold mornings, but frequently they had to be observed during warmer periods, when the bees were active.

Pieces of scutellum, and soil samples, were examined in the laboratory using a Zeiss stereoscopic microscope, with magnifications of $6\times$, $10\times$, $16\times$, $25\times$ and $40\times$.

OBSERVATIONS

NEST A In 1961, I had the opportunity of examining a nest of *spinipes* collected in the woods of Cidade Jardim, in the city of S. Paulo. The nest was pear-shaped, and on a trunk or branch of only 6 cm of diameter (measured just under the nest). During a storm, the nest fell to the ground and broke and gave me the chance to examine its interior.

At the base of the nest I found a large, thick and compact structure, shield or basin. This scutellum was 12–13 cm thick, and 35–40 cm across, in one direction. In the opposite direction it was broken, at the time I took the measurements. Unfortunately, when the nest fell, the position of the scutellum in relation to the tree branches and to the other structure of the nest was not recorded. The inside of the broken nest had been exposed to rain, during the storm.

I could see that the shield-like structure was made of several layers, that in some places were breaking apart, probably because of their exposure to rain. Aware of the observations made by Salt in *amalthea* (a related species), a close inspection of these layers revealed sheets of exoinvolucrum between the layers. The involucrum is a structure composed of many irregularly spaced membranes that involves the brood combs and sometimes the honey and pollen pots. I apply the term exoinvolucrum to the harder or more brittle and exterior part. By probing carefully on the more compact part of the shield, sheets were observed that probably belonged to the exoinvolucrum. Between them was a yellowish or brownish material.

What seemed to be the more recent part of this material, faced the brood region of the nest. It was yellowish and friable. Many legs and other parts of dead bees could be detected in it. As I went through the compact mass, it became difficult to dig and uncover the primitive involucrum sheets.

The structure of this nest's scutellum was not studied in detail since long exposure to rain probably altered its characteristics.

NEST B On July 21, 1962, a nest was collected from a tree located in a ravine, in Saltinho, Usina Ester, Cosmópolis, State of S. Paulo. It was built on a fork, at approximately 6 meters above ground. When the tree was felled the nest was partially broken but the scutellum suffered little.

The nest measured approximately 48 cm (diameter) \times 60 cm (high). The scutellum had a general U form and was built along both sides of two branches. The scutellum, from its lower part, to both higher parts of the U, measured 39 and 45 cm. The inside floor of the U had a width of 21 cm. The base of the scutellum was a little below the tree fork. Within 20 cm of this base, it gradually increased in bulk, until it reached the "valley" floor (the lower inside part of the U). This 20 cm comprised the bulkier part of the scutellum. The whole scutellum weighed 11.90 kg.

Both arms of its U shape were at the sides of the nest. What seemed to be a dead liana, went thru one of these arms. There were three or four membranes of the brittle exoinvolucrum covering the outer part of the scutellum. Near its inside surface, were storage pots and brood combs.

After rasping the surface of the scutellum that was in contact with the tree branches, three samples of material were taken and examined (#1—near the valley-floor region; #3—near the base; and #2—midway between both places).

Sample 1 appeared granular, yellow-orange in color, with many Acarina, parts of dead bees and remains of bee cocoons. There were also dark masses which broke up and showed a granular structure when prodded with a needle. These dark masses were much softer than in the other two samples. I found, too, large cocoons and bacillus-shape black excrements. These cocoons and excrements belonged to an inquiline that lived in the scutellum.

Sample 2 was generally granular, dark brown in color. There were fewer Acarina than sample 1, but included remains of dead bees, small sheets of bee cocoons and 2 or 3% of small crystals, hyaline or yellowish. These crystals fractured easily, upon slight pressure of a needle tip. There were also other hyaline grains, somewhat different in appearance and very hard. These were sand grains. Altho far less numerous than other crystals, they were not uncommon. Vegetal fibers were plentiful. Some

sand grains were in actual contact with such fibers. Some areas were covered with a white material. Dark masses were present. When rasped with a needle, they formed whitish "ribbons" with many granules.

Sample 3 also was granular in structure, with many brownish-red granules. Its appearance was clearer than that of sample 2. Some stratified, thin deposits of clear yellow granules alternated with a dark substance. When prodded with the tip of a needle, this dark substance broke up, showing a somewhat granular structure. A few hyaline crystals were present which were easily fractured. Remains of bee cocoons and dead bees were found. A quantity of what seemed to be white mycelia were seen. No Acarina were present in this sample.

One of the arms of the U-shaped scutellum was examined inside. Much loose granular material, of a brownish color, was found. In many places there were deposits of clear yellow granules. White and cream colored ones were also common. The granules, size was about the same as the brown ones. A gradient in color could be seen, between the yellow and white grains. Sometimes this occurred also in the same deposits. In other places, there was a similar transition between clear yellow and orange-rose grains, or between clear yellow and bordeaux color grains, passing thru pink tinges. Live Acarina and remains of dead ones were seen. Many dark and nearly always flat masses were found.

In some places there were many white filaments, apparently fungi mycelia. In other places, chiefly where the scutellum had contact with the tree branches' small puffs of varying size were found. They were light yellow, with a somewhat cotton-like consistency. In some places they were larger and of irregular form. The nature of this substance was not determined.

Some of the primitive outer exoinvolucrum membranes of the nest, could be recognized among the varied materials found inside the scutellum. These membranes had a core of small pieces of vegetal matter. By this characteristic they were found and traced in the scutellum. The interior of the scutellum had a stratified appearance, altho the strata varied and were not always present.

In several places it was possible to see some insect larvae, in silk-lined tunnels. Inside these tunnels, were dark excrements

of bacillus-like shape. The larvae are now being reared, for identification.

The surface of the scutellum varied. The outer part of it was of a darker color and in places it had a thin coat of propolis. The inside surface, i.e., the surface near the brood combs, was lighter in appearance and mostly covered by a thin cerumen. Near the tips of the U, the inside surface was lighter in color which in several places was covered by white granular material, over a dark substance. Scattered over this white layer were the remains of the cerumen coat. It seemed that the bees had removed much of the superficial cerumen, leaving the white granular material exposed. The surface, in such places, was pitted, showing the marks of the bee mandibles that removed much of the cerumen. There were many small grains ranging from white below, to yellow-orange above, but it seemed that in this case the orange color was due to the cerumen of the upper strata.

Outside and inside surfaces had spots of clear yellow granular material. Over both surfaces, some of these spots were elongated and sometimes became progressively brownish over their extension. These spots certainly were the dejections of moving bees. [Five or six hard hyaline grains, possibly sand, were found.]

It must be stressed that on the inner and outer surfaces of the scutellum, as well as inside it, numerous dark, flat, relatively small masses could be seen. Removing them with a needle's tip, the remains of cocoon walls could be found. These flat masses made up nearly all of the scutellum's outer surface and a greater part, if not most of its inner surface. When prodded, they produced numerous orange or cream colored and brown small grains.

In order to study the nature of the excrements of this bee three young bees were caught. A slight pressure on their abdomen resulted in voiding their feces. Upon drying, the clear yellow granular material found on the scutellum was found to be the bee's excrements.

NEST C This nest was at a height of 4-5 m, upon a tree fork having three branches from the banks of the Pirapitingui river (Saltinha, Usina Ester, Cosmópolis, S. Paulo State). Under the fork supporting the nest, the tree trunk had a diameter of 12 cm. I was told that the nest was a relatively new one, about 6 months old.

The nest was 54 cm high and had a diameter of 35 cm.

The whole nest, including the scutellum, was enveloped by several sheets made chiefly of vegetal matter (exoinvoluera). Between each sheet was a large empty space. On the scutellum's inner side, one or two of these membranes were visible in some places.

The scutellum was a continuous structure, but two regions could be recognized. One, below and in front of the nest, had a valley or U shape. The other, at the back of the nest, showed a shield-like form. Two lianas or small branches passed thru the scutellum near the floor of the "valley."

The front and under region of the scutellum had a U or valley shape. Each arm of the U was along one of the two more extreme branches of the fork. From its narrow base, below the tree fork, the scutellum went upward, in 10 cm, increasing progressively in thickness until the "valley" floor which was 9 cm. wide. From the valley floor upward, both arms of the U became increasingly slender. From the tips of the U, to the scutellum's base measured 18 and 19 cm. Between both tips, the distance was 21 cm. This part of the scutellum weighed 450 g.

The "valley" portion of the scutellum was connected to the shield-like upward region, which started at the back of the "valley" or U. One of the arms of the U was built around the outer side of one of the tree fork branches. After flanking this branch, it, too, contacted the shield.

The shield region was made between and along both extreme branches of the 3 branch fork. The middle branch nearly divided this part of the scutellum in two, and was to a large extent encased by it.

On the tip of one of the arms of the U. near the place where it contacted the scutellum's shield region, were 3 long plates. The central one was about as thick as the membrane of the exoinvolucrum, but the others were much thicker, up to 16 mm approximately. Breaking one of these thicker plates showed the primitive membrane of vegetal matter in the center of the plate. Covering it, in both sides, were deposits of hard material. Over the surface of one of the plates was a white finely granular material. Under it was a dark layer. When prodded with a needle, this dark material gave up a white granular substance. It is possible that primitively there was another layer over the white grains, but this was not as evident as in Nest B.

Inside, the broken arm of the U region the primitive exoinvolucrum membranes made chiefly of vegetal matter were recognizable. Other membranes of the exoinvolucrum, near but outside the scutellum, appeared to be in process of thickening.

On the internal surface (that nearer the brood combs), was a large quantity of the clear yellow granular substance, as well as many flat, small, dark deposits, commonly contiguous. In some places the clear material predominated, but in others the dark deposits were dominant. Under them, some remains of the combs' cocoons could be found. Over this side of the escutellum surface, was a thin and irregular coat of cerumen and propolis. In some places the deposits of both substances were thicker, but still thin. A much larger and thicker deposit of transparent propolis covered an area of approximately 1×1 cm. The twin marks of both bee mandibles could be seen everywhere on the surface, showing that some material was rasped and taken elsewhere. Some of the superficial cerumen apparently was removed. Parts of dead bees were common on this inner side of the scutellum.

The surface of the outer side of the scutellum's lower part was far darker than that of the upper and inner sides. This surface was coated with propolis, mostly thin, but of varying thickness. Under it, there was far less yellow granular material than that found on the upper and inner surfaces of this U part of the scutellum. The flat, small, dark deposits, generally contiguous, were even more common than on the scutellum's inner side, comprising most of this outer surface, and contributing greatly to its darker appearance. Under them, remains of brood cocoons were found. At the back of the scutellum's shield-like region, the surface was coated with a brighter, more transparent propolis than that found in the U region. Under it the masses of yellow small grains were clearly visible. Some lumps of shiny green propolis (or perhaps propolis embedded with a green material) were found in some places, on the outer surface (seldom on the internal surface). Rarely were there parts of dead bees on the outer surface, contrary to what was found in the inner one. Dispersed over the outer surface of the scutellum, a few brownish granules were seen even though there were no deposits of them. Possibly their presence was accidental, scattered during the manipulations of the scutellum.

Inside one of the scutellum's arms, and inside the shield region, 50% of the content was, in many places, made of the clear-yellow granular material. There were also whitish and brownish-red small grains, and hues (including cream) intermediate between these colors as well as between them and clear-yellow. Often, in the same deposits these color transitions could be observed. The brownish-red granules were in part loose. Some of them were being carried over the bodies of the many Acarina present. Many small, dark deposits, generally forming strata, were found. Among them some remains of brood cocoon walls were seen. White filaments (mycelia?) were present in some places. There was a cavity lined with silky threads. In a sample from inside the shield-like portion of the scutellum, one sand grain was found, as well as a small black hard grain, not identified. Remains of dead Acarina were plentiful. Dead bees were also found. This inside part of the scutellum had a general stratified appearance (although an irregular one) due to the succession of dark deposits and clearer granular material.

The small, dark, flatish deposits found everywhere, when prodded with a needle, broke up showing numerous small grains, orange to brown, or cream colored.

NEST D This nest was on a tree near the Jaguari river (Ilha, Usina Ester, Cosmópolis, State of S.Paulo). It was 50 cm high. In a lateral view, it had a maximum width of 42 cm. Seen in front of the entrance, its width measured 29 cm.

The scutellum extended almost from the base to the top of the nest, on its rear side. The scutellum was not entirely removed, and so its shape could not be studied in detail. However, it was easy to see that it was shield like. Its upper part was taken away, for a closer examination. It had to be chopped out. This was not easy because of its hardness. Most of the scutellum was left intact to avoid endangering the nest.

The scutellum was covered on its outer side by an exoinvolucrum of 4-6 membranes (in all nests there is always a space between the scutellum and the membrane next to it). On the inner side of the scutellum, the brood combs confined it. There were also a few sheets of the exoinvolucrum near this inner side of the scutellum.

Directly connected with it or near the uppermost part of the

scutellum, were several thick and hard plates. When cut, they showed the core of vegetal matter characteristic of the exoinvolucrum, with propolis outside it. They had only a little granular material. Over the surface of the scutellum's upper part, as well as over the surface of some membranes near it, there were many places with a layer of a white, granular material. This white layer was not continuous, but rather spotty. There were remnants of cerumen and of a granular material impregnated with cerumen, in a higher position in relation to the white layer. In a few cases, propolis was present, instead of cerumen. It seems, by the twin marks of mandibles, that the bees removed in such places much of the original cerumen, uncovering the white layer.

The inner surface of the scutellum had also plenty of soft cerumen, partly lining it or present in small lumps. Under this coat, in some places, there was plenty of dark, apparently flat deposits. Propolis was far less common. Relatively few spots of clear yellow granular material were seen.

The outer surface of the scutellum was well covered with cerumen and little propolis. A few brownish-red small grains adhered. Several big cracks were lined with cerumen. In general this outer surface was dark and composed of many small, dark, flat, contiguous deposits, under the cerumen coat.

Some primitive membranes of the exoinvolucrum on the inside part of the scutellum were recognizable by the vegetal fibrous matter that makes their core.

Most of the bulk of the scutellum consisted of a brownish-red granular material. Clear-yellow granules were far less numerous than in colonies B and C. However, in some places they comprised about 50% of the materials present. White and cream colored granules were seen, too. Sometimes, in the same deposits, colored granules ranging from clear yellow to white, clear yellow to brown, and white to brown occurred. Small hyaline crystals easily fragmented upon slight pressure of a needle tip. Many layers of dark, nearly always flat deposits, alternating with other materials gave a stratified general appearance to a cut of the scutellum. Together with these layers were found remains of the walls of the brood cocoons. When prodded with a needle, the dark deposits broke up into brown or cream colored granules.

Several tunnels or cavities lined with silk were found. Among them were dark excrements, with a bacillus-like shape (far more numerous than in colony B) obviously associated with some immature insect living there.

Remains of dead bees and dead Acarina were observed inside the scutellum. One grain of sand was found near the inner surface of the scutellum.

NEST E Several years ago, in S. Paulo, a colony of *T. spinipes* established itself voluntarily, at the top of a *Cariniana estrellensis* (Raddi) O. Ktze. tree. The nest was at a height of 6–7 m. and reached with difficulty. Since I did not wish to remove nor to destroy the nest, observations were made with me perched near it. In such circumstances, the nest was not examined as thoroughly as would have been possible in another situation.

The nest was 50 cm high with a lateral width of 36 cm. and started at a tree fork. The upper part of the trunk went approximately through the middle of the nest. Other tree forks were inside the nest. Just under the nest, the tree trunk had a diameter of 6 cm. The largest lateral branch had only more or less 1 cm of diameter.

The scutellum began at the tree fork, surrounding the tree trunk. It had two portions. One was a half ring or belt, with a thickness of only 5 cm. encircling part of the tree trunk. This half ring merged, on both ends, with the base of the shield-like part of the scutellum. This shield, starting at the tree trunk, extended almost to the top of the nest which was inclined slightly backward. Below, it rested in part on the chief lateral branch of the tree fork at the rear of the nest, opposite to the nest's entrance.

The distance from one margin of the scutellum, to the margin of the other side was 19 cm. Its shield-like form only protected the nest's back, leaving the nest's frontal area unprotected. In this region, cutting through some membranes of the involucrum, were a cluster of honey pots.

The scutellum was completely covered by two sheets of the exoinvolucrum. On the inner side of the scutellum, exoinvolucrum membranes also occurred. The scutellum's upper region had a plate, under which there was an empty space, followed by

the main part of the scutellum. This plate was merely an extension of the scutellum which on both surfaces was limited by sheets of exoinvolucrum. They could be recognized by their core of fibrous plant material, between layers, on both sides, of propolis. Unfortunately, samples from the central region of the scutellum's inner side were unobtainable. Those I could take were mostly at the scutellum's edge.

One of the samples from the lower part of the scutellum showed a relatively large region of dry, brittle, red-brown bright glass-like propolis. Elsewhere, similar propolis was found as small layers, at the surface, or as small deposits, under it. This lower region of the scutellum contained innumerable small brown and cream colored grains, and many dark masses.

Deposits of yellow granules were relatively few, but white or cream ones, mixed with the brown small grains were common. A sheet of the exoinvolucrum was recognizable inside this part of scutellum, because of its core of fibrous plant material. Remains of dead bees were common. Also found was a relatively large broken part of what was probably a quartz grain which was hard to fracture. Acarina were covered by cream and brown granules as well as small pieces of dry propolis.

Inside the tabular expansion of the scutellum, already mentioned the brown small grains predominated. However, from 5 to 10% of all granules had a yellow-orange hue. Some granules were between this color and brown. Many dark deposits were seen. They were mostly thick, but in general appeared stratified with some thin clearer strata or empty sheet-like spaces between the dark deposits. Remains of dead bees and dead Acarina were common. The dead bees were in great part inside the dark masses.

Inside another sample, also taken at the scutellum's upper edge region, the brown small grains predominated. Three sand grains were seen. There were countless Acarina and two insect larvae. Some zones had white mycelia.

At the edge of the "shield", or slightly inside the nest's upper region, the surface was covered by a predominantly white, salt-like, finely granulated material, over dark strata. This white layer was patchy and of irregular thickness. In places it still had over it some cerumen or granular material impregnated with cerumen. Often there was a color gradient between the

light brown cerumen and the white layer. A color range was also seen in one place, between clear-yellow (above) and white (below).

In other samples taken at the surface's outer portion, or slightly on its inner and lower side, the surface was almost black, soft, and flat, although by no means even. It was apparently made by adding relatively small, dark and flat deposits, the limits of which were far less clear than in the surfaces of other nests. In places, a few areas of propolis and some cerumen could be seen. The remains of dead bees were also found on the surface, covered by cerumen or by the dark deposits. These dark deposits were found not only at the scutellum's surface, but also made up most of its interior. In some places they showed a decidedly stratified aspect, but not in others. When prodded with a needle, the dark material broke into a mass of brown and cream colored small grains, or with a yellowish hue (more rarely). Among the dark deposits it was possible to see some remains of the bees' brood cocoons.

An elongated bee excrement, laid over the outer surface of the scutellum, was partly granular and clear yellow, and partly dark, not visibly granular. However, when this dark portion was prodded with a needle, it also broke up into clear yellow granules.

The samples taken from this nest were small, and not much stratification was seen.

SOIL SAMPLES

The scutella of nest B and C, at first seemed to consist largely of clay or earth. Examination of samples of soil was then made under the stereoscopic microscope ($6\times - 40\times$).

In the region of Cosmópolis, the soils are of glacial, permo-carboniferous (Setzer 1949: 55) or diabasic-basaltic, triassic origin. Several samples were collected near nests B and D.

Two samples of glacial soil appeared granular with a great amount of sand grains of different sizes. Some of them were not hyaline. Another sample, possibly of mixed origin, when prodded with a needle gave off a finely divided material, probably clay.

The samples of soil of diabasic origin had much less quartz grains, although they were still common. A great part of this

soil was a finely divided, non-granular material, clear reddish-brown ("purple") in color. There were also some shiny black grains. In other places, the diabasic soils frequently have much more sand.

In Jardim Guedala, S.Paulo City, where nest E is located, the tertiary red soil is rich in sand grains.

For a discussion on the soils of the State of S.Paulo, see Setzer (1949).

DISCUSSION

When referring to the papers of other authors, I have placed between parenthesis, following the Latin name I have adopted, the original nomenclature used by the authors cited.

SHAPE H. von Ihering (1903 (1930: 66-70, 81) called scutellum a structure of *spinipes* (=*ruficrus*) nest . . . "with the form of a basin or shield". One of the pictures he published (see Schwarz 1948, plate 6), shows the scutellum only at the side of a nest. Another picture (1903 (1930: 66-70)) presents the same structure as one large L, which is in part under and in part at the rear of the nest. H.von Ihering also said that the scutellum is . . . "generally compact, yet it presents here and there some irregular corridors, full of dead bees".

Silvestri (1904: 136), said that the scutellum of a nest he examined in Misiones, Argentina . . . "circuncated completely the tree bifurcation on which it rested: it is a true and solid foundation". It seems to me, by the pictures he published, that this nest also extended itself to the sides of the nest (his picture 8 should be viewed upside down). If this is done, at the lower right is a space that probably was occupied by one arm of the scutellum; and at the picture's lower left there seems to be another arm, the upper part which possibly was concealed by the exoinvolucrum. From Silvestri's words, and from the pictures, I presume that this scutellum had a U shape.

Mariano Filho (1911: 127) wrote that the scutellum—at the nest base—was a "globular mass . . . sometimes extending itself a little to the sides". The "globular mass" concept is difficult to understand, in view of his additional description in which he states that the scutellum had ". . . a position in form of shield or rampart". Possibly he meant that the scutellum was in an

upward position, as that in which a shield is held. At any rate, it is impossible to consider a shield as a "globular" structure.

In a previous paper (1910: 21), Mariano Filho wrote that the scutellum "was situated in the [nest's] base, extending itself upper on" . . . In that paper, he also published a picture presented by H.von Ihering, that shows the scutellum as an oblique, nearly vertical wall (Schwarz 1948, plt 6). It seems to me that Mariano Filho used the expression "globular mass" only because the scutellum's outer surface is rounded. At any rate, no truly globular scutellum was found by myself or other authors.

In all nests described in the present paper, the scutellum or its major part had a general shield-like or a U shape, or both.

In nest B, the scutellum had a definite U form. It was built along both branches of a tree fork. In fact, this scutellum was nearly divided in two U's, each half being at opposite sides of the tree fork.

In nest C, the shield-like portion of the scutellum was in an upward position, at the back of the nest, among three branches. The middle branch nearly divided it in two, in its upper region. This scutellum extended forward and downward, at the base of the nest. There it formed a U or "valley", mostly under the nest and partly encircling it. Both arms of this U were built along the two more forward branches of the tree fork. In short, this interesting scutellum had a shield-like or C shape at the back of the nest, and U or valley form in the lower frontal region of the nest.

Nest D and E had a scutellum with only a shield-like form, in an upward position.

Nests A, B, C, D, E showed that the scutellum's form can be variable. However, in all five cases, the chief structure was rounded, convex, in the nest's outer side; and rounded, concave, on the inner side.

SIZE AND WEIGHT In nests B, C, D, E, (the ones in which size was measured), regardless of shape, the scutellum extended from the base of the nest to its upper region. However, the scutellum is always shorter than the whole length of the nest, because it is enclosed by a few membranes. The presence of such outer sheets was first noted by H.von Ihering (1903 (1930: 69)).

In nests C, D, E, in side view the scutella's widths were less than the entire widths of the nests. However, when seen from the rear, these scutella occupied most of the nests' widths since in such cases it was shield-like and situated at the nests' back.

One of two nests of this species, described by H. von Ihering (1903 (1930: 66-70)), had a remarkable scutellum. As mentioned, it was somewhat L-formed, occupying not only most of the nest's rear, but nearly all of its lower half too. I cannot understand how it measured only 32 cm (height) \times 10 cm (width).

The largest scutellum examined was nest B. It weighed 11.90 kg and had a maximum height of 45 cm and a width of 21 cm (measured in a direction parallel to both U arms of it). It was nearly double the weight of the one examined by Silvestri (1904: 136), which was only 6 kg.

Mariano Filho (1910: 21) said that . . . "the older the nest, the bigger the scutellum and, (singular thing!) the fewer the number of the hive's inhabitants". I cannot see why this should be. Nest B had the largest scutellum I saw, and it also seemed to be the most populated nest.

PROTECTIVE EXOINVOLUCRUM COVER The scutellum is never seen from the exterior. In its outer side, as shown by H. von Ihering (1903 (1930: 69, 81)), it is always enveloped by a few sheets of the involucrum. In the nests I examined, the outer part of the scutellum was covered with 2 to 6 membranes. Between each sheet and also between the scutellum and the sheet next to it, there is a relatively large space, where the bees may circulate. This part of the involucrum is brittle and made chiefly of a core of vegetal matter lined on both sides (except outside the nest) with at least some propolis, and at times with plenty of it. I think that it should be called exoinvolucrum, in contrast to what could be named the endoinvolucrum (the inner sheets made of cerumen).

Silvestri (1904: 137) stated that "the substance that constitutes most of the peripheric part [of the nest], in its major part seems to be dung of herbivorous [animals]".

Mariano Filho (1911: 127) wrote that the plant fibrous material used to make the "peripheric involucrum" was collected by this bee from dry cattle dung.

Michener (1946: 194), writing on the brittle peripheric mem-

brane of *T. corvina*, said that "This arrangement must serve a useful purpose for at the attack of an enemy (e.g. the author) the outer thin coating is promptly broken and bees can swarm out from many parts of the nest to attack the intruder".

In my opinion, one of the chief roles of the exoinvolucrum is to protect the scutellum's surface, and that of the whole nest, against rain. Since propolis is a water soluble substance, the outer surface of the exoinvolucrum does not have it.

Lindauer (1957: 71) stated that *spinipes* (= *ruficrus*) and *T. (T.) hyalinata* . . . "adapt around the nest a cap of manure and mud, that resembles very well the cracked bark of a tree". In fact, *spinipes* nests viewed from the ground, seem to be covered by mud. I was deceived, too, until I could closely examine the exoinvolucra.

INSIDE AND OUTSIDE CONSTITUTION H. von Ihering (1903 (1930: 81)) thought that although the scutellum is "built chiefly of clay, it however contains such a proportion of wax, that the whole thing forms a solid mass. . .".

Silvestri (1904: 136) and Bertoni (1912: 142), said that the base of the nests of *spinipes* (= *ruficrus* for them), was made of "vegetal earth."

Mariano Filho (1911 : 127) stated that the scutellum . . . "consists of a globular mass of resistant clay, much propolized." . . .

Salt (1929: 438) wrote of the nest of *amalthea*, a related species: "by receiving the dirt and the waste of the nest above, this network might successively be transformed into the hard, cellular mass found below it." The network was probably what I call the exoinvolucrum. The work of Salt was important to the present research, because it stimulated me to investigate the possibility of similar origin of the scutellum.

In nests B, C, D, the outer surface of the scutellum was well covered with propolis. In all nests here examined in detail, the scutellum's inner surface had patches of propolis and cerumen, but more commonly there were small, flatish (altho not even), more or less rounded deposits of a dark material. The limits of each of these dark small deposits generally were unclear, but in many cases it was possible to see that they were separately laid down and incorporated in the scutellum's surface. Remains of

dead bees and spots of clear yellow granules were not rare at the scutellum's surface.

These spots of yellow granular material were found mostly on the scutellum's inner side. Some of them were elongated and partly dark in color. However, when prodded with a needle, the dark portion broke up, transforming itself into a yellow granular mass. The roundish spots of yellow granules certainly were the dejection of resting bees, flattened by the workers.

In order to confirm the origin of this material, three young bees of nest A were captured and their excreta examined. It was easily seen that this excreta is the clear yellow granular material found in all nests.

Near the upper part of the scutellum, a finely white granular substance, salt-like, was frequently found. It was always over a dark layer. However, this white material must have been under a stratum of cerumen, the remains of which were seen sometimes over the white layer, and partly impregnating it. Why this happens, is not known.

The inside, that is, the bulk of the scutellum consists of several materials grouped in four categories: A—dark deposits, often in strata, together with the remains of the bee cocoon's walls; B—more or less free granules; C—remains of dead bees; D—Acarina, alive and dead.

Inside or outside the scutellum, the dark material, when prodded with the tip of a needle, broke up into a mass of small grains, yellowish or cream-brown in color. On the surface of nest E, the dark substance was soft, but on the other nests it was generally firm. In both cases, their granular nature was the same.

The deposits that exist on the base of the cocoons of prepupal and pupal brood cells of *spinipes* showed also the same granular structure when prodded with a needle.¹ Moreover, among the dark deposits that exist in the scutellum, it was possible to find the remains of the bee's brood cocoons. These were frequently still adhered to the dark deposits, as they always are on the bottom of the cocoons. All this demonstrates, unmistakably, that the dark material constituting most of the scutellum, comes from

¹ Observations of this will be published in another paper on brood cells and combs.

the bottom of the brood cocoons of *spinipes*. In other words, this dark material is the excreta of prepupae, which void them after making their cocoons. H. von Ihering (1903 (1930 : 87)) said that excrements and larval skins were found on the bottom of the brood cocoons of meliponins. However, he did not mention the presence of this material in the scutellum.

In nest C, the granular materials was chiefly a clear yellow color (50% of total matter present); this was also true in parts of nest B, and apparently in much of nest A (which was the only one not examined with the stereoscopic microscope). In the other nests, altho not so common, small yellow grains were present, too.

There was a large proportion (the predominant one in nests B, D and E), of small grains more or less reddish-brown in color. In nests B, C, D, E (the ones examined in detail) there were also many white and cream colored granules and even some bordeaux and pink ones (nest B). At first, it was thought that perhaps the reddish-brown ones were earth. However, a comparison with samples of soils taken near the original nests sites, showed that this was not the case. For one thing, sand grains were a rarity in the scutella. Yet, sand was common in the soils examined. True, the scutella had other hyaline crystals, but these were not of quartz since they were easily smashed by a slight pressure of a pin's tip.

The scarcity of sand in the scutella, shows that earth is either not normally present, or is of very little importance there.

The origin of the reddish-brown, and cream colored granules seen in the scutellum is substantiated by the fact, that they are easily obtained by prodding with a needle the dark deposits made of prepupal excrement. In many places the small grains were loose with many Acarina among them. It seems that the Acarina or more probably the insect larvae also found inside the scutellum, were responsible for freeing the granules from the dark deposits.

The alternation of layers of dark material with layers of yellowish granules, and also the presence of exoinvolucrum sheets, gives a general stratified look to a cut thru the inside of the scutellum. Yet, this is not always the case, inasmuch as sometimes the deposits were irregular in form.

Writing briefly on the nests of *spinipes* (=*ruficrus*), Silvestri (1904: 136) and Bertoni (1912: 142) said that there was, at the nest's base, a "thick" or a "compact" mass of "vegetal earth." Probably such "vegetal earth" was, in fact, the scutellum and granular material.

In short, contrary to what was thought, the scutellum of *T. spinipes* is not made up of mud or vegetal earth. The conclusion that the scutellum is predominantly derived from the bees' excrements—prepupal and adult—is an entirely new concept. It also shows that this species gives a building destination to a matter that most mellioponins simply throw away.

LOCATION—Nest A arrived at my home in a tree trunk cut just below the nest. Possibly the tree fork at the nest's base was lost. It is not certain, however that there was one on the nest's base. Yet, higher up, the nest incorporated other tree forks.

All other nests examined were built over a tree fork, which had two or three branches. Not only these lower branches and some upper ones, but even lianas were wholly or partly incorporated into the nests and scutella. This incorporation of tree branches was a common characteristic of all nests examined. Obviously, the heavy scutellum must always contain or rest upon branches capable of supporting it.

Silvestri (1904: 136) referred to such structure on a tree bifurcation.

Mariano Filho (1911: 127–128) also saw a scutellum at a tree fork, . . . "a fact generally common when the nest implants itself in little developed trees. In such cases the interior of the nest is frequently transversed by small secondary branches, that help in giving more stability to it."

It is interesting to notice that most nests are built on trunks or branches of relatively small diameter. Just under the nests here examined, diameters of the tree trunks were as follows: A = 6 cm; B = 13 cm; C = 12 cm; D = 4, 5 cm; E = 6 cm.

It seems amazing that such heavy structures are often made on thin branches. One would even think that *spinipes* build their homes on the most slender branches capable of supporting their heavy nests. A possible explanation is that the scutellum would be of little use, as a defense, if an enemy could attack from above. On slender trunks or branches it seems very diffi-

cult to attack from above because such branches are at tree tops or at the sides of trees, in places generally difficult to reach from neighboring branches capable of sustaining a medium size mammal. Yet, this hypothesis does not seem to explain the case of nest B, where the branches were not so thin. It must be considered, however, that nest B was an old one and when first built, certainly the tree branches were thinner.

FUNCTION Mariano Filho (1911: 127) wrote that . . . "it is because of the scutellum's heavy weight that the monstrous nest maintains itself in most complete stability." This theory of the "stability" function was also adopted by Ducke (apud Schwarz 1948: 268) and R. von Ihering (1940: 402-403).

When examined in relation to their position, the scutella generally (but not always) had their outer convex surfaces directed against the place from where a climbing enemy could menace the nest. On the opposite side, their inner concave surfaces somewhat protected the vital parts of the nests: the brood combs and the storage pots.

In my opinion this shows that the scutellum has a defensive role. Yet, this "defensive" function does not tell the complete story. In nest D, for instance, the tree trunk was at the back of the nest, but not fully incorporated into it. The scutellum was mostly at one side of this trunk. On the other side the nest was not so well protected by the scutellum. In nest E, the situation was even more revealing. The upper part of the tree trunk passed thru the middle of the nest. From the place of the trunk where the nest began, the scutellum went upward in a somewhat inclined and outer direction. Its shield-like shape left a space, between the shield margins, of 19 cm. Thru this region, not protected by the scutellum, a mammal climbing the trunk could easily attack the nest. In fact, after removing a few sheets of the exoinvolucrum, I came upon some honey pots. True, at the base of the nest, even in this little protected region, there was also a belt of scutellum some 5 cm thick, around the tree trunk. However, this was manifestly insufficient to stop or to delay an attack by a climbing mammal.

Lindauer (1957: 71, 73, 78) wrote that "The stingless bees do not make cleaning flights as our *Apis* does, but leave the excrements in their own nest, in special places, where other refuse is

also put. This garbage heap is removed from time to time, but they [the bees] always let some remain, in order to leave a disagreeable odor to ward off nectar and pollen thieves.'' Lindauer did not mention any permanent refuse heap. He did not speak of the scutellum of *spinipes* (= *rufifcrus*), which in all probability was not seen by him.

In my opinion, the prevailing smell inside the nests of nearly all species of meliponins, is decidedly good. True, the scutellum has a slightly disagreeable odor, but it certainly would not repel an enemy with approximately the same olfactory reactions as man.

Another possible role of the scutellum would be as a reservoir of heat. This huge structure is always thermally isolated from the outside by 2–6 membranes of the exoinvolucrum and by the spaces between them.

Weyrauch (1942: 64) wrote that a similar external involucrum, in a neighbor species serves to . . . "maintain in the interior of the nest a higher temperature than that of the ambient." This was a nest of *amalthea* (= *trinidadensis*, identified by Schwarz 1948: 252), in which the existence of the scutellum is not yet known.

The scutellum certainly absorbs and keeps some of the nest's heat. On cold nights, part of the heat received during the day would then be transferred to other parts of the nest. However, the intensity of this exchange of heat must be very small (it was not measured).

H. von Ihering (1903 (1930: 81)) stated that, in his opinion, the scutellum . . . "seemed destined to give greater solidity and resistance to the nest." This certainly must be true, and one is easily convinced by the scutellum's massive structure. However, H. von Ihering's statement is a general one, and must be further elaborated.

Silvestri (1904: 136) said that this structure was . . . "a true and solid foundation" at the base of the nest he examined. As told here in the discussion of its shape, it seems to me that this scutellum had a U shape. At any rate, Silvestri's pictures showed the scutellum to have at least one inclined wall. Therefore, it was not, in my opinion, a mere base foundation.

Mariano Filho (1911: 127) called the scutellum "a globular

mass," and this might imply an absence of walls. However, when the shape of that structure was discussed, it was shown how his own words were at variance with that "globular" concept.

In view of Mariano Filho's conflicting considerations on this matter, it seems advisable not to take his words as meaning an absence or near absence of walls in the *spinipes* (= *ruficrus*) nests he saw. In the nests of *spinipes* which I observed, the scutellum always could—or at least a part of it—be considered as a wall. One may say the same in relation to the nests described and pictured by H. von Thering (1903 (1930: 66–70); in Mariano Filho 1920: 21).

Obviously, this huge structure must have an important adaptive role, or it would not be formed in the course of evolution. Actually, *spinipes* is a very successful bee and even resists man's persistent efforts to eradicate it.

In my opinion, the nest construction (storage pots, brood combs, etc.) of the Meliponinae must always be directly or indirectly fixed on a strong wall. In all nests of well known species, this is a common constant. Of course, not all individual pots or combs are directly anchored to a wall, but they are connected to other pots, combs, etc., that in turn are firmly attached to a wall. In some cases the wall may be built by the bees themselves. The scutellum is an example of this. The presence of a strong wall is—I think—a general rule or "law" of the nests of the Meliponinae. The same cannot be said of the nests of other bees as, for instance, the Bombinae (bumblebees).

As stated, the nests of *T. spinipes* are located on relatively thin branches, mostly at the tree tops or sides. Obviously such small round branches do not afford the wide and large wall surfaces that seem so necessary to the nests of meliponins. I believe that the shield-like scutellum is well suited to provide the supporting walls these bees need. This is, in my view, the scutellum's chief role.

In nest B, the branches of the tree fork were larger than those of the other tree forks here mentioned but still not to be considered large branches. In this case, the scutellum had a U shape. Both arms of the U greatly increased the surface that the two branches could offer.

SIMILAR STRUCTURES IN OTHER SPECIES In the nest of a related species, the Central American *T. (T.) corvina*, Michener (1946: 193-194) described a structure that probably was also a scutellum. Inside the nest of this bee, he found several thick ($\frac{1}{4}$ "- $\frac{3}{4}$ ") layers of hard material. It . . . "required a hatchet and considerable prying to cut and remove large pieces." In places the layers, when . . . "not distinct formed a total thickness of two and one half to three inches." There was an outside brittle thin layer. The nests were built on tree branches.

The general shape of this structure was not described, but probably *T. corvina* has a scutellum, too. In fact, sometimes *T. spinipes* also makes such thick layers, near or connected to the scutellum (see obs. of nest C and E). And besides, Michener found a massive structure $2\frac{1}{2}$ "-3" thick (approximately 6.5 cm-7.5 cm). It has a comparable one, among the nests of bees: the scutellum of *T. spinipes*. There are other points of similarity between the nests of *corvina* and *spinipes*. The "stratified or laminated" "yellowish solid material" "among the inner layers of hard wax" in a *corvina* nest, resembles the condition found inside the scutellum *spinipes*. Also the construction of nests upon branches and the covering of the nests by an outer brittle layer, were found in both species (Michener, o.c.; Schwarz 1948: 276-279).

In the opinion of Schwarz, *corvina* is a "near relative" of *ruficrus*, here named *spinipes*. However, both bees were considered by Cockerell to be two varieties of the same species (Schwarz 1946: 276).

The presence or absence of some kind of scutella should be investigated in *amalthea* (= *trinidadensis* and/or *silvestriana*). Inside hollow trees, Bertoni (1912: 142), in Paraguay, found in this species a thick structure at the nest's base. Salt (1929: 438), in Colombia, said that "Upward from the lower batumen, for 15 cm, extended a hard, brittle, coarsely cellular mass of cerumen . . ."

Myers (1935: 132), in Trinidad, found that an external nest of *amalthea* (= *silvestriana* Vach.) had the outside . . ." covered with exceedingly hard, small chambered resinous material, incorporated with much earth. This layer was very thick at top and bottom" . . . It must be remembered that some authors

thought that the scutellum of *spinipes*, too, was made of propolis or cerumen, and earth.

Weyrauch (Schwarz 1948: 252) wrote that a nest of *amalthea* (= *trinidadensis*), captured at San Ramon, Peru, had an "outer envelope consisting of a thick mass of coarsely chewed leaves." "This envelope is thoroughly compact and contains no hollow spaces." In a previous paper, describing another external nest of this species, Weyrauch (1942: 63-64) did not mention any strong wall. However neither did he deny its presence. Possibly it escaped his attention.

It seems that when *amalthea* builds external nests, it has peripherical walls that perhaps may have some points of similarity with the scutellum. As already mentioned, the internal nests of *amalthea* may also have a related structure. For the time being, the name scutellum should be used only in connection with the internal massive walls of *spinipes* and—probably—*corvina*.

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REPRODUCTION IN THE SOCIAL BEES¹ (HYMENOPTERA: APIDAE)

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ABSTRACT

Data are presented concerning the reproduction in Bombini, Apini and Meliponini.

1—*Melipona quadrifasciata*. All queens of this species mated only once and outside the hive. A queenless colony continues to kill virgin queens for almost 100 hours after being dequeened. Queens return from the mating flight with the male genitalia. A queen, marked on her return from her only mating flight, lived for three years and one month. Males average 1,156,850 spermatozoa. A recently mated queen had, in oviducts and spermatheca, 1,018,333 sperm. Since she returned with the male genitalia we concluded she mated with only one drone. Another queen which had laid only 30 eggs had 950,000 in the spermatheca indicating that about 97% of the sperm from the drone had reached the spermatheca: an efficiency of the ejaculation much greater than in *A. mellifera*. A spermatheca examined immediately after the queen returned from her mating flight showed spermatozoa moving at a speed of 11.4 to 16.0 mm per minute.

2—*Trigona (Tetragonisca) jaty*. Males gather in resting groups close to the entrance of the hive during swarming. These 3,000 males dispersed a few days after the queen was mated. More than one virgin flies from the mother colony to the new one during swarming. After a virgin is successfully mated remaining virgin queens are imprisoned in isolated waxy cells and die there. Spermatheca were found to contain 108,260 sperm.

3—*Trigona (Plebeia) droryana*. Males of this species, attracted by the

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smell of the orchid, *Trigonidium obtusum*, tried to mate with this flower. An anaesthetized queen placed on the flower (whose scent is believed to resemble that of the virgin queen) attracted males which tried to copulate with her in the normal position of solitary bees, male above female.

4—*Trigona (Scaptotrigona) postica*. During swarming as many as three virgin queens flew to the new home. A day later only one queen was found. A virgin queen born in a normal hive, but not mated, is tolerated for about 15 days, then she is persecuted by the bees and killed. Up to 8 virgin queens were found in a queen-right hive. Males leave the hive after a few days and then congregate in groups within 20–250 cm of the hive entrance. Greatest flight activity is between 1:00 and 3:00 P.M. Males feed directly from flowers within a flight range of about 600 meters, which is comparable to the flight range of workers. Males gathered in groups before a hive, may belong to several different colonies.

5—*Apis mellifera*. Sperm counts of male ejaculations varied from 1,600,000 to 9,610,000 with an average of about 6,000,000. No correlation was found between body weight of drones and sperm count. Drones from one hive lacked spermatozoa. A queen which had been laying for 40 days had 5,600,000 sperm in her spermatheca. Two queens dissected on their return from the mating flight showed 43,440,000 and 69,590,000 sperm in their oviducts and spermatheca suggesting matings with 7–12 drones on a single flight. Sperm in the spermatheca were actively motile for approximately 60 minutes before becoming non-motile. Their motility was slower than sperm of *M. quadrifasciata quadrifasciata*. There is a noticeable tendency, increasing as you move up the scale of social behavior, towards an increase in the genetically active population among social bees.

Most studies on reproduction of social bees have been made with the honey bee, *Apis mellifera L.* It was the common belief some 20 years ago that the queen of *Apis mellifera* mated on her nuptial flight with only one drone. Roberts (1944) (6), however, using strains of bees with genetic markers, showed that each queen in his apiary had copulated with at least two males. Triasko (1951, 1956), comparing the volume of spermatozoa in the ejaculate of a single drone with the volume found in the oviducts of the queen on her return from the nuptial flight, concluded that 7 males inseminated the queen on a single flight. Taber (1954), using genetic markers, also concluded that an average of 7 males mate with each queen. Taber and Wendel (1958) analyzing data from Taber, Peer and Cale, concluded that queens mate with 7 to 10 drones. Taber (1954) found the average duration of the nuptial flight to be 13 minutes.

Alber (1956) working with Sicilian bees, showed that queens mate only once during bad weather.

Peer (1957) obtained important data on the distance travelled,

by both queen and drone, during mating flights. His main conclusions are summarized in Table 1.

Table 1. Data (Peer 1957) showing a decreasing percentage of fertilization with increasing distances of mating flights.

Distance between queens and apiary	Number of queens	Number of queens that began laying eggs			% of queens that began laying eggs
		15th day	23rd day	31st day	
In the apiary	9	9	—	—	100
5.1 km	9	8	—	—	89
9.8 km	9	6	—	—	67
12.9 km	12	—	3	2	42
16.3 km	12	—	—	3	25
18.3 km	11	—	—	—	0
22.5 km	11	—	—	—	0

Oertel (1956), by caging drones and then releasing them at various distances from their hives, showed that the percentage of returning drones decreased with increasing distances. Beyond 4 km no drones returned. It would seem, therefore, that the maximum flight range of queens would be approximately 12.3 km, that is 16.3 km (Table 1) minus 4 km travelled by the drone. This corresponds with the maximum range for bee flight found by Knaffl (1953).

Mackensen and Roberts (1947) found the average number of sperm in the spermathecae of queens to be 5,730,000 while drones average 9,000,000 sperm in the seminal vesicles.

In a detailed study of the evolution of behavior and of bionomics of the social bees it is necessary to make comparisons between honey bees and other social species. Bumblebees (Bombini) are the most primitive social Apinae. Fairchild and Barret (1906) observed *Bombus (Fervidobombus) fervidus* (Fabricius) mating on a tree trunk six inches above the ground. Frison (1927) obtained controlled mating within a glass dish in the species *B. (F.) americanorum* (Fabricius), *B. (Pyrobombus) bimaculatus* Cresson, and *B. (P.) vagans* F. Smith. Sladen (1912) suggests that *B. (Hortobombus) ruderatus* Fabricius mates in the open air.

Kerr and Krause (1950) observed that the queens of *Melipona quadrifasciata quadrifasciata* Lepeletier returns from her nuptial flight with the male genitalia attached. The exhaustive studies and research data of Nogueira Neto (1950, 1954) on swarming

in the stingless bees (*Meliponini*) have been available to us since 1949.

GENERAL METHODS

Direct observations have been made of the mating habits of several species of stingless bees and *Apis mellifera* L.

The Jaycox method (personal communication) of counting sperm has been used: 2 gr. of soluble starch is dissolved in 98 cc of double-distilled water. This solution can be used for two weeks if kept under refrigeration. The spermatheca is placed in 1 cc of the 2% starch solution and broken to release the sperm. A medicine dropper is used to homogenize the mixture and to put a drop in the Levy-Hauser haemocytometer. Counts of sperm are made rapidly under 400X magnification.

RESULTS

Results, and special methods are given for each species studied.
1. *Melipona quadrifasciata quadrifasciata* Lep. A queenless colony was placed in a Nogueira Neto hive (Nogueira Neto 1953) on a table inside the laboratory. A rubber tube 70 cm long and 3 cm in diameter led from the entrance of the hive through a hole in the glass window so bees will fly freely. This tube was cut 10 cm from the hive, and a piece of glass tube was used to connect the cut rubber parts so that every bee leaving or entering the hive could be seen. Observations were made continuously from 6 A.M. to 6 P.M.

First experiment. A *First Experiment* Jan. 27, 1958—A strong hive of *Melipona quadrifasciata quadrifasciata* was divided into two parts. The queenless part had ample brood and was used in our experiments.

Jan. 28, 1958—Bees began to work normally.

Jan. 29, 1958—The activity of workers was intense due to good weather. At 4 P.M. a virgin queen, killed by the workers was carried from the hive.

Jan. 30 and 31, 1958—Three more virgin queens were killed and carried out.

Feb. 1, 1958—A virgin queen left the hive. When she returned she was marked, clipped and released into the hive. She began laying in six days. (This queen lived until March 3, 1961, or for three years and one month).

The elimination of the virgin queens indicates that "queen substance" from the original queen was still present in the hive. The last virgin queen was killed 98 hours after the hive was divided and made queenless and the first virgin queen accepted by the colony was born 120 hours after the colony was made queenless. The accepted virgin queen was anaesthetized when she returned from her mating flight and the male genitalia were found in her genital tract thus confirming the observations of Kerr and Krause (1950). It was, therefore, concluded that queens of this species are inseminated only once.

Second experiment B *Second Experiment* Eighty-four hours after the queen had been killed in a colony, a virgin queen left the hive on her mating flight. She was dissected when she returned and the male genitalia were found attached. The spermatheca was removed, placed in the starch solution and examined microscopically, before the sperm were released. The sperm were moving like a dense cloud within the spermatheca. We could see that the cloud was formed by thousands of spermatozoa heads and made 10–14 complete turns per minute or at a speed of 11.4 to 16.0 mm per minute. This is a fantastic speed in comparison with the rate of movement in other animals. The sperm continued their movement for an hour and a half after the return from the nuptial flight when the spermatheca was ruptured and examined. The total number of sperm found in the mated queen two hours after the nuptial flight was 1,058,333 (standard deviation of $\bar{x} 65,000$) being 985,000 found in the oviducts (standard deviation of $\bar{x} 65,000$) and 33,333 (standard deviation of $\bar{x} 7,600$) which had already entered the spermatheca. Another queen that had laid 30 eggs showed 950,000 sperm (standard deviation of $\bar{x} 55,000$).

Two drones were dissected and their spermatozoa counted; the first produced 1,088,750 ($\pm 60,500$) and the second 1,225,000 ($\pm 56,750$). The number of sperm found in the drones and queens leads to the conclusion that queens are inseminated by only one male, confirming our suspicions when we saw the male genitalia inside the queen. So far as we could determine queens made only one mating flight.

If one touches the male genitalia while dissecting, ejaculation begins and proceeds in such a way that practically no sperm remain in the seminal vesicles. It seems probable that pressure,

when the genitalia of the drone enters the vagina of the queen, is the stimulus which causes ejaculation. The movement of the spermatozoa into the spermatheca is a point deserving comment. We found that 97% of the sperm deposited in the oviducts entered the spermatheca. This can only be possible if chemotaxis is the motivating force. The strong movements of the spermatozoa confirms this belief.

2. *Trigona (Tetragonisca) jaty* F. Smith

Material A young colony being formed by swarming, and an observation colony.

Observations No signs of swarming occurred until Oct. 3, 1959. A mated queen observed in the colony could still fly but had not started egg laying. Upon dissection 108,260 sperm were found in the spermatheca (Jaycox technique). She weighed 22.45 mg. On the same day we found a virgin queen imprisoned by workers among resin and wax.¹ There were no sperm in her spermatheca which suggests that virgin queens of *Trigona* go to the new colony before making their mating flight. Following the killing of the queens a new virgin left the mother colony and joined the swarm in the afternoon of Oct. 19, 1959. She mated on the same day and began laying a few days later.

During the period when queens were ready to mate an enormous group of about 3000 males stayed in front of the hive. After mating very few males remained even though about 30 males were still in front of the hive four days later.

On July 22, 1961 we again observed the beginning of swarming of a colony of *T. jaty*. Sixteen days later the new queen laid the first four eggs.

3. *Trigona (Plebeia) droryana* Friese

Kerr and Lopes (1962) were lucky in finding a species of orchid, *Trigonidium obtusum*, whose flowers attracted only males of *Trigona (Plebeia) droryana*. Tearing the flower apart they found that a small dark spot on the sepal was responsible for the attraction. The males tried desperately to copulate with that spot. When an old queen, anaesthetized with CO₂, was placed on the sepal, males immediately tried to copulate with her in the nor-

¹ Dr. Paulo Nogueira-Neto informed us that detailed information on this behavior of *T. jaty* is reported in a paper of Mr. E. Juliani recently sent to press.

mal position used by all known solitary bees, that is, male above female.

4. *Trigona (Scaptotrigona) postica* Latreille.

Material and Methods: A colony of *Trigona (Scaptotrigona) postica* was used, and observations were done on swarming and on the behavior of males flying around the hive.

On July 20, 1961 about 10 workers of this species tried to invade a hive of *T. (Friesomelitta) freiremaiai* Moure. On the following day one of these workers was observed placing communication marks (for communication in *T. (Scaptotrigona) postica* see Lindauer and Kerr, 1960). To avoid loss of the colony the hive was removed from its original location and returned five days later. However, on August 5th about 10–15 workers of *Trigona (Scaptotrigona) postica* began to again force their way into this weak colony. Three days later about 200 bees entered the hive and took possession of it, and a small group of males began to fly around it. On the morning of August 9 the swarm was examined and about 500 bees but no virgin queen was found. At 2:00 P.M. another examination was made and again no virgin queen was found. At 5:00 P.M. the hive was again inspected and a non-physiogastric queen was found, showing that the queen arrived five days after swarming began. This queen was dissected but no sperm was found in either oviducts or spermatheca. On August 11th two active virgin queens were found in the hive but were not mutually antagonistic. The following day only one queen, slight larger than the day previous, was found and on August 20th she laid the first eggs.

Usually from 1–8 virgin queens may be found among the workers in hives of *T. postica*. Hebling, Kerr and Kerr (1962) observed a virgin queen from emergence to 17 days before she was killed by the workers.

Due to the significance of male behavior in reproduction and because *T. (Scaptotrigona) postica* hives provide an abundance of males throughout the year, it was decided to observe them. Usually these males congregate in groups resting quietly on branches, tree trunks, leaves, grass, etc, about 50–200 cm from the hive entrance. Colonies of *T. postica* always have large numbers of bees flying within a radius of 200 meters of the hive.

On April 16, 1960, a relatively cold day, samples of bees flying

around the hive entrance showed only workers. Males began to appear about 12:00 (noon) mostly in resting aggregations. At 1:00 P.M. we counted 265 resting males. Results from samples taken from flying bees after 1:00 P.M. are shown in Table 2. After 4:00 P.M. the number of resting males decreased to thirty, some of which made occasional flights.

Table 2. Samples of flying *Trigona postica* collected within 130 cm of the hive entrance.

Time	13.05	25 worker	25 males
13.15	4	"	62 "
14.22	6	"	17 "
14.45	14	"	18 "
15.10	3	"	21 "
15.22	33	"	6 "
15.55	17	"	16 "

Marking individual bees showed that when a male leaves the hive he stays with other resting males and flies very little. Length of flight periods increases with increasing age and reaches a maximum 10–15 days after the first flight is made. Males stayed in the swarm for various lengths of time. The maximum time a male remained alighted was 9 minutes.

A piece of wood placed close to the hive served as a locus of a group of males. Each day this rod was moved 20 cm further from the hive. Males continued to settle on the rod when it was 250 cm from the hive, but when we increased the distance to 270 cm no males came to it. We can, therefore, state that the maximum distance from the hive at which *T. postica* will establish a congregation spot is between 250 and 270 cm.

Very often wasps and honey bees were attracted to aggregations of *T. postica* and would lick the legs of the males of a given swarm. From 80 *postica* males washed in 6 cc of water we obtained 2.95% solids which shows that the males have some secretion on their bodies. The source of this substance is not known.

Of 136 males collected, 62 or 45% had large quantities of pollen on their bodies. Stingless bees, therefore, retain the primitive character of solitary bees in which males are able to earn their own living. In October 1960, a male of *T. (Scaptotrigona) postica* was observed taking nectar from a flower of *Senecio brasiliensis* Less. and in July 1961 a male of this species was found

collecting nectar in a flower of *Dombeya acutangula* Cav. We also observed that pollen collected by workers and drones are nearly always of the same species.

In a group of 800 males of *T. (Scaptotrigona) postica* there was a male of *T. (Scaptotrigona) bipunctata* (Lepeletier) from a hive 20 meters away. On another occasion two males *T. (Nannotrigona) testaceicornis* (Lepeletier) were found in a swarm of *T. postica* males. On March 30, 1962 a male of *Meliponula bocandei* (Spinola) (an African species) participated in a congregation of *T. postica* males for five days, and flew around the *postica* hive.

We believe that some kind of odor common to several species is responsible for these odd attractions. The number of males in an aggregate varies from a few to thousands.

On April 21, 1960 large numbers of *T. postica* drones were marked with pigment and released at various distances from the colony. Up to 600 meters males returned to the hive in great numbers but beyond 650 meters no drones returned. For this species, 600 meters is about the maximum range of flight for males; 680 meters is the maximum flight for workers of *T. postica*.

By marking drones from 4 hives we found that male aggregations contained drones from all 4 hives. This indicates that in this species panmixia is the rule.

5. *Apis mellifera* L.

Method: Sperm counts were made on drones and queens of *Apis mellifera ligustica* and *Apis mellifera adansonii* both as a check on our experiments with the stingless bees and as a comparison with other data mentioned in the literature.

The males used were large adults collected at the hive entrance or returning from flight. They were pressed with the fingers and the product of the ejaculation was collected with a Mackensen and Roberts tip and syringe and immediately placed in a 2% starch solution. We believe the reason our counts are smaller than those of Roberts and Mackensen may be due to the amount of ejaculate which remained on the walls of the syringe and within the drone. However, we wanted to obtain counts from the spermatozoa which are ejaculated, and not from the ones which are found in the vesicles.

All drones were weighed before sperm counts were made.

Results: We found the average number of spermatzoa in drones to be 6,000,000 with a range of 1,600,000 to 9,610,000. One hive had males with no sperm at all. Since this is probably due to genetic factors the data are not included in the paper. We found no correlation between body weight and the number of sperm in adult drones.

Of seven queens examined, 4 returned virgin after the first mating flight. One queen, dissected after laying for 40 days, had 5,600,000 sperm in the spermatheca. A second queen dissected immediately after her return from a 15 minute mating flight had 190,000 sperm in the spermatheca, 69,400,000 in the oviducts or a total of 69,590,000 sperm. Since an average drone can supply 6,000,000 sperm, we suggest that this queen was inseminated by 11-12 drones. In a third queen, dissected after her second flight which had lasted 9 minutes, we found only the right oviduct full; not a single sperm was found in the left oviduct. There were 43,-200,000 sperm in the right oviduct, 240,000 sperm in the spermatheca for a total of 43,440,000. This suggests she mated with 7 or 8 males. These data agree closely with the findings of Taber and Wendel (1958).

Observation of the spermatheca, under a Zeiss photo-microscope with episcopy attachments, showed that immediately after the nuptial flight the sperm are moving but not with the tremendous speed of *M. quadrifasciata* sperm. The velocity of *Apis* spermatzoa was estimated to be 0.05-0.07 mm per minute which is about 150 times slower than with *M. quadrifasciata*. One hour after the mating flight the sperm of *A. mellifera* were almost quiescent while in *M. quadrifasciata* the sperm were in continuous movement when the spermatheca was ruptured one hour and thirty minutes after the nuptial flight. Thus it would appear that the mechanism responsible by the migration of sperms to the spermatheca in *Apis mellifera* is not the same as in *Melipona*. A physical cause is suggested by these data.

GENERAL CONCLUSIONS

Since a female bee receives and stores, during a short mating period early in life, all of the sperm she will ever receive and because males are haploid and, barring mutations, produce only a single genetic type of sperm, it is evident that the greater the

number of males with which the queen mates in random matings the greater will be the genetically active population. Conversely, the greater the number of females which mate with a single male the smaller will be the genetically active population. From the data presented we can state that there is a tendency among social bees to increase the genetically active population. Males of solitary bees inseminate more than one female. Males of stingless bees (*Meliponini*) lose their genitalia during the mating act and therefore can inseminate only one female and virgin queens make only a single mating flight. Finally we have the *Apini* females that can rid themselves of the remaining male genitalia and can be inseminated by 7-12 males.

With increasing social organizations there is an increase in the capacity to store sperm.

Experiments on *Melipona* show that chemotaxis is the only acceptable theory to explain the migration of sperm into the spermatheca. The theory of chemotaxis, however, may not be valid for all species (*Apis mellifera* for instance).

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The authors wish to express their thanks to Doctors Helbert R. Jaycox, Warren Whitcomb and P. Nogueira-Neto and Mr. S. Taber for many helpful suggestions.

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ERRATUM

In Volume LXX No. 3, page 168 of the Journal of the New York Entomological Society the name of the first species of louse in the annotated list beginning on page 168, should have read:

Enderleinellus longiceps Kellog and Ferris
instead of
Enderleinellus nitschi Farenholz

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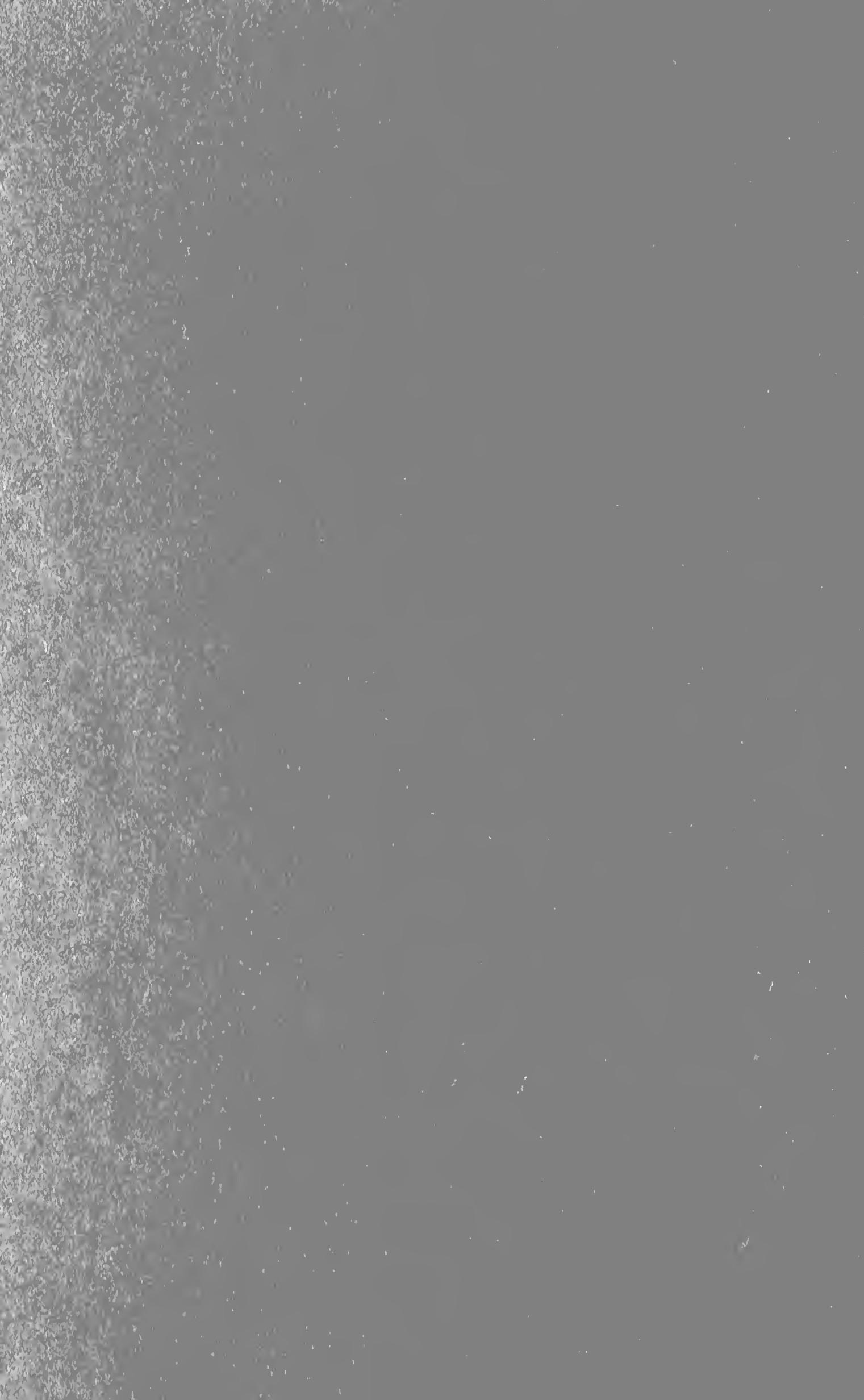
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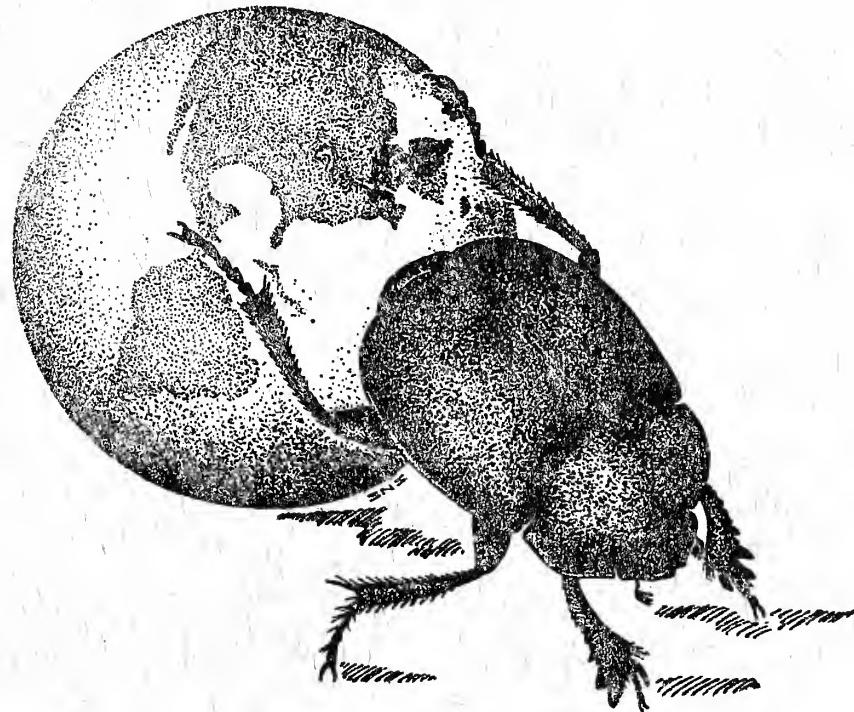
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EVALUATION OF THE WAX AND SCENT GLANDS IN THE APINAE (HYMENOPTERA: APIDAE)¹

CARMINDA DA CRUZ LANDIM

UNIVERSITY OF SÃO PAULO, BRAZIL

RECEIVED FOR PUBLICATION AUGUST 22, 1962

ABSTRACT

The wax glands of bees of the subfamily Apinae are actually specialized hypodermis which internally covers the exoskeleton in certain abdominal areas. Characteristics of glandular tissue are distinct only during the period of active secretion, and is difficult to distinguish from unspecialized hypodermis during the inactive period.

These glands are situated in sterna IV to VII in honeybees (*Apis*) and from terga IV to VII in the meliponids (*Melipona* and *Trigona*). In the bumblebees (*Bombus*), the most primitive social Apinae, they are found both in terga (IV to VII) and sterna (IV to VII), though more developed dorsally. In *Euglossa*, a unique non-social group of Apinae the wax glands are restricted to tergum VII. There is no marked difference in the histology of these glands among the species observed.

Glandular tissue, histologically similar to the wax glands, was confirmed within the mandibles of *Apis* and the meliponids. The scent glands were studied in *Bombus* workers, *Apis* workers, and meliponid queens. Scent glands were situated in the anterior part of tergum VII and showed no histological difference among species examined.

Bees of the subfamily Apinae (Michener, 1944) offer numerous interesting problems because of their remarkable social organization.

Recently, comparative studies on the evolution of Apinae bees have been promoted in the Department of General Biology of F. F. C. L. Rio Claro by my colleagues and myself in diverse aspects. The evolution of the wax and scent glands in Apinae presented here is based upon observations of their anatomy and histology.

MATERIAL AND METHODS

The following species were studied:

Euglossa cordata Linnaeus—females; *Bombus atratus* Franklin—workers; *Melipona quadriasciata anthidioides* Lepeletier and *Melipona rufiventris* Lepeletier—drones, workers and queens; *Trigona (Scaptotrigona) postica* Latreille; *Trigona (Friseome-*

¹ Submitted for inclusion in the **Herbert F. Schwarz Memorial Volume** (1962) but delayed in publication due to lack of space, cf., 70 p. 214.

litta) silvestrii (Friese) and *Trigona (Friseomelitta) freiremaiai* Moure (M.S.)—drones, workers and queens; *Apis mellifera ligustica* Spinola drones, workers and queens.

For histological observations the material was embedded in paraffin, sectioned 10 to 15 μ in thickness and stained with Delafield's hematoxylin and eosin.

WAX GLANDS The wax glands in bees consist of specialized hypodermis which covers internally the exoskeleton of certain abdominal areas. In an adult bee the hypodermis is represented as a thin epithelium apparently syncytial, because the cell boundary is invisible. In certain areas of the body, the nuclei of such epithelia are hardly visible and the exoskeleton appears covered by a basal membrane which apparently is not cellular (Fig. 1). Structure typical to glandular tissue does not appear in the

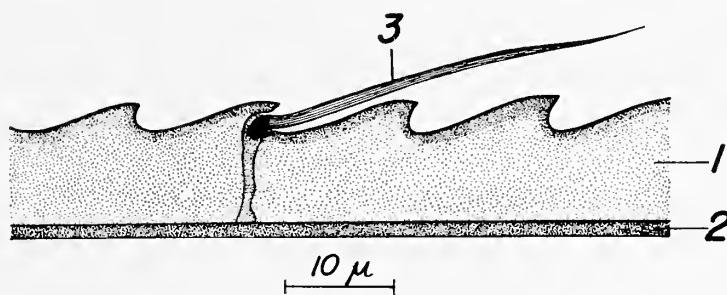


Fig. 1. Chitinous cuticle limited internally by the basal membrane: 1. Chitinous cuticle, 2. basal membrane 3. hair.

entire abdominal hypodermis but only in certain restricted areas of some sex or caste.

In the non-social bees, wax glands have not been recorded, even in those rather close to the social bees. According to von Ihering (1903), however, Moebius found nests of the genus *Euglossa* internally covered by wax or a similar substance. The histological observation of *Eu. cordata* proved the occurrence of a wax gland in this species. It is very small, and confined to the penultimate abdominal dorsal segment (Fig. 2 A).

Wheeler (1928) wrote that, the males and queens of the genus *Bombus* can produce wax. Their wax glands are situated both dorsally and ventrally in the abdomen and the glandular epithelium appears on terga IV to VII and sterna IV to VII (Fig. 2 B), though glands are more developed dorsally. This greater development is caused by the larger number of glandular cells, their greater height and greater amount of granules within them.

In *Melipona* and *Trigona* the wax glands are dorsally situated, on terga IV to VII (Fig. 2 C) as in *Bombus*. In all drone specimens examined, including even those of the most primitive species (*Trigona (Friseomelitta) silvestrii* and *Trigona (Friseomelitta) freiremaiai*), I could detect no trace of wax glands. Nevertheless, Drory (1873, 1874 and 1877) reported the wax production by males of *Melipona marginata* and *Melipona scutellaris*, which was doubted by Schwarz (1948) but reconfirmed by Kerr (1951), who observed a number of males of *Melipona marginata* with wax

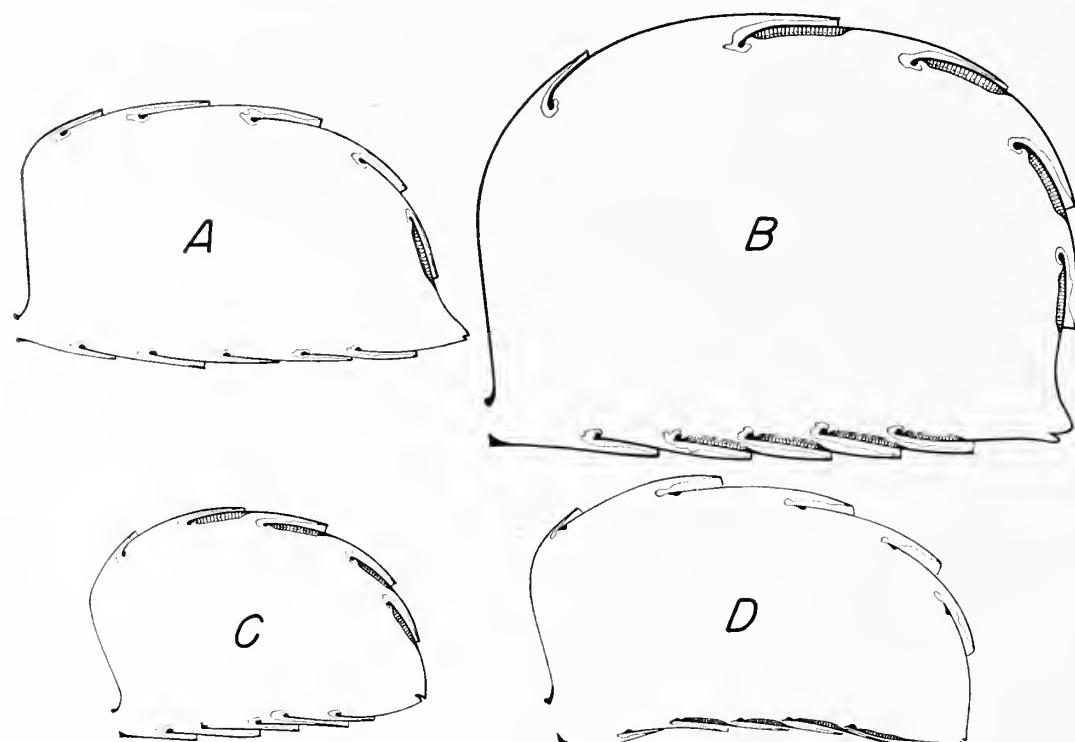


Fig. 2. Localization of wax glands: A. *Englossa cordata*; B. *Bombus atratus*; C. *Melipona quadrifasciata*; D. *Apis mellifera*.

scales on their backs. On the other hand, the queens of all species examined show well developed wax glands with the localization similar to the workers. Finally, the glandular specialization appears in *Apis* only ventrally, occupying sterna IV, V, VI, and VII of workers (Snodgrass, 1956). (Fig. 2 D.)

Since Dreyling (1903) it has repeatedly been reported that the wax glands of *Apis* suffer development and degeneration according to age throughout adult life. Confirmation of this was possible when I observed *Melipona* and *Trigona* of various ages. In the young workers immediately after emergence of *Melipona quadrifasciata anthidioides*, the hypodermis localized in terga IV,

V, VI, and VII presents no particular differentiation, shows a flat epithelium with a cell boundary hardly visible (Fig. 3 A). Corresponding to the increase of activity and age these cells become taller and the cell boundary becomes more clearly visible (Fig. 3 B). At the climax of wax production, the glandular cells are seen remarkably tall and longitudinally striated, containing numerous basophilic granules within. At this stage the empty spaces appear among cells (Fig. 3 C), representing inter-cellular bridges connecting the cells, as seen in a transverse section (Fig. 4).

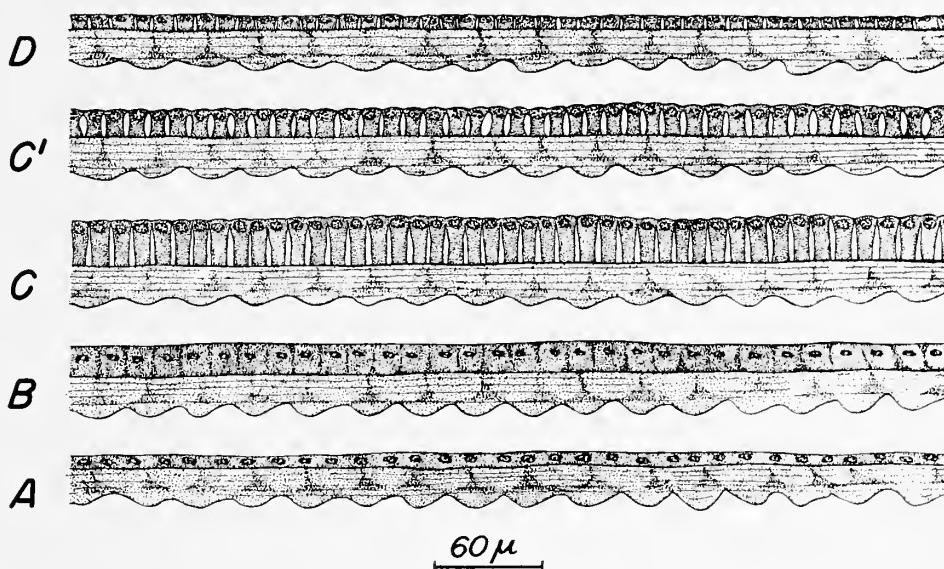


Fig. 3. Secretion cycle of wax glands: A. Undifferentiated hypodermis; B. Beginning of differentiation; C. Active period of wax secretion; C'. Beginning of degeneration; D. Degenerated glandular epithelium.

The most active period of wax secretion, that is, the period of the greatest development of the glands, in *Apis*, occurs between 12 and 18 days (Rösch, 1927). For *Melipona*, such determination has not yet been made. Kerr and Santos Neto (1953) observed the participation of the workers of *Melipona quadrifasciata* in the wax manipulation from the 12th to after the 35th day. In *Trigona (Scaptotrigona) xanthotricha* the wax production begins on the 34th day and continues to the 50th day (Hebling, Kerr, and Kerr, 1962). However, the age at which a bee presents the maximum activity of glands may vary considerably according to the needs of the hive. When the wax is urgently needed for the hive, even the foraging bees, which under normal circumstances had ceased wax production can again produce.

After the active period of wax production, the glands may suffer degeneration and the glandular epithelium becomes similar to the undifferentiated state (Fig. 3 D). In general, the regression of wax glands does not happen immediately at the end of the secretion cycle and relatively well developed glands may be found in foragers that are not too old.

The hypodermis, once differentiated into glandular epithelium during the active period of wax production, does not return to the primitive undifferentiated state in the post-active period, but shows the apparent sign of degeneration (Fig. 3 D).

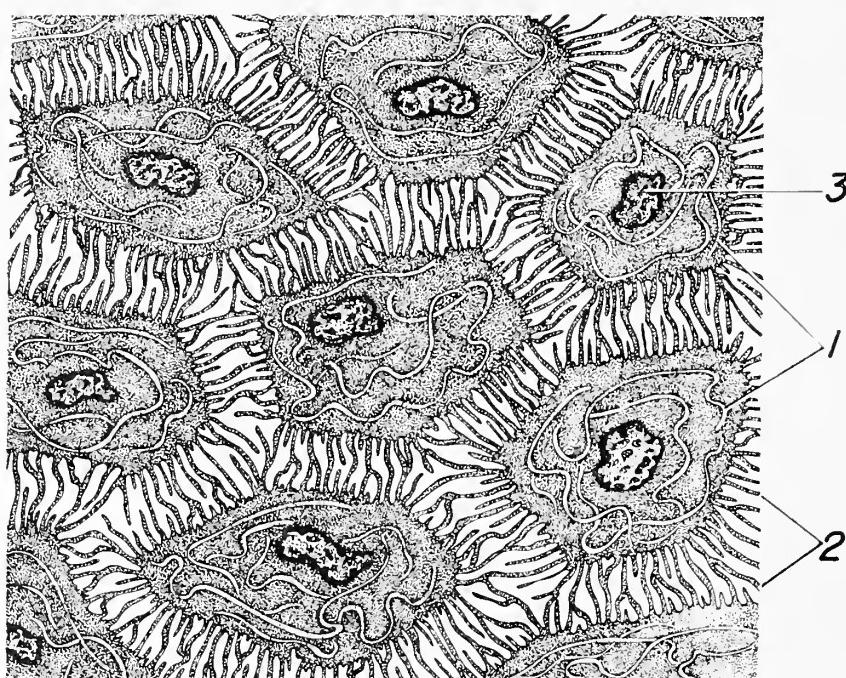


Fig. 4. Transverse section of glandular epithelium at maximum wax secretion: 1. Epithelial cells; 2. Intracellular bridges; 3. Nucleus.

During the secretion of wax it is possible to see fat cells and oenocytes closely connected to glandular cells. The fat cells on the surface of the secretory cells are flat and smaller than those found in other areas of the body (Fig. 5). Such deposition leads to the presumption that the oenocytes and fat globules may play a role in wax elaboration, probably producing lipids which enter into wax composition.

No essential histological differences were detected in wax glands of different genera and species examined. All species studied revealed a similar cycle of secretion and histology.

The secreted wax changes to the cuticular scales which cover the secretory area. How wax reaches beyond the integument

after production is still unclarified. In *Apis* the cuticle upon the wax mirrors bears a thin and semi-transparent structure. Lewke (1950) described the occurrence of canaliculi penetrating the cuticle, whereas Reiman (1952) failed to confirm the existence of such pores. He assumed that the wax may penetrate the cuticle dissolved in a special secretion which then evaporates upon reaching the external surface. This results in the condensation of wax and ultimate production of solid scales.

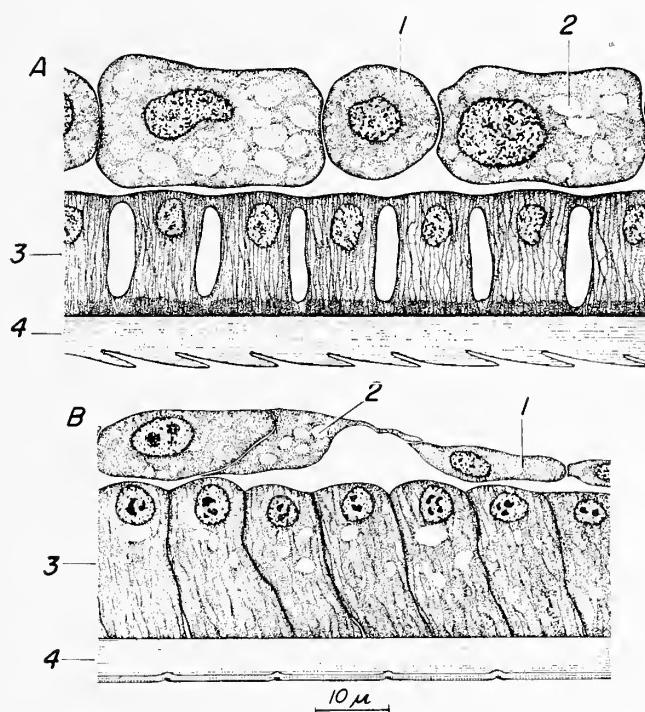


Fig. 5. Relation among oenocytes, fat cells and wax cells during the active period of secretion: A. *Melipona quadrifasciata* ♀; B. *Melipona rufiventris* ♀. 1. Oenocyte; 2. Fat cell; 3. Glandular epithelium; 4. Chitinous cuticle.

In the bees examined (except *Bombus*) no special structure in the cuticle covering the glandular area could be verified. The cuticle is transversely striated, as it is in other areas of the body. In *Bombus* the cuticle is remarkably thick, with special striations and having pores filled with an amorphous basophilic material, well stained by hematoxylin (Fig. 6).

After secretion, the wax forms the scales which are later removed by the hind legs (Fig. 7). In order to determine whether diverse depositions of glands correlate to the structure of hind legs, the relative length of each segment was measured, but no statistically significant correlation was found. The legs were

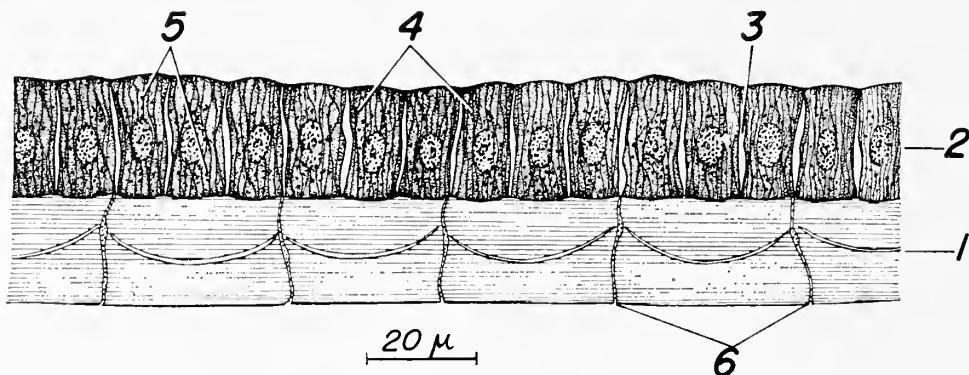


Fig. 6. Glandular wax epithelium at maximum secretion in *Bombus atratus* ♀: 1. Chitinous cuticle; 2. Glandular epithelium; 3. Intracellular space; 4. Intracellular striation; 5. Intracellular granules; 6. Intrachitinous pores.

inserted more laterally in *Apis*, *Melipona* and *Bombus* while more ventrally in *Trigona*.

WAX MANIPULATION Bees use the legs and mandibles to model wax for building and repairing the hive architecture. Orözi-Pál

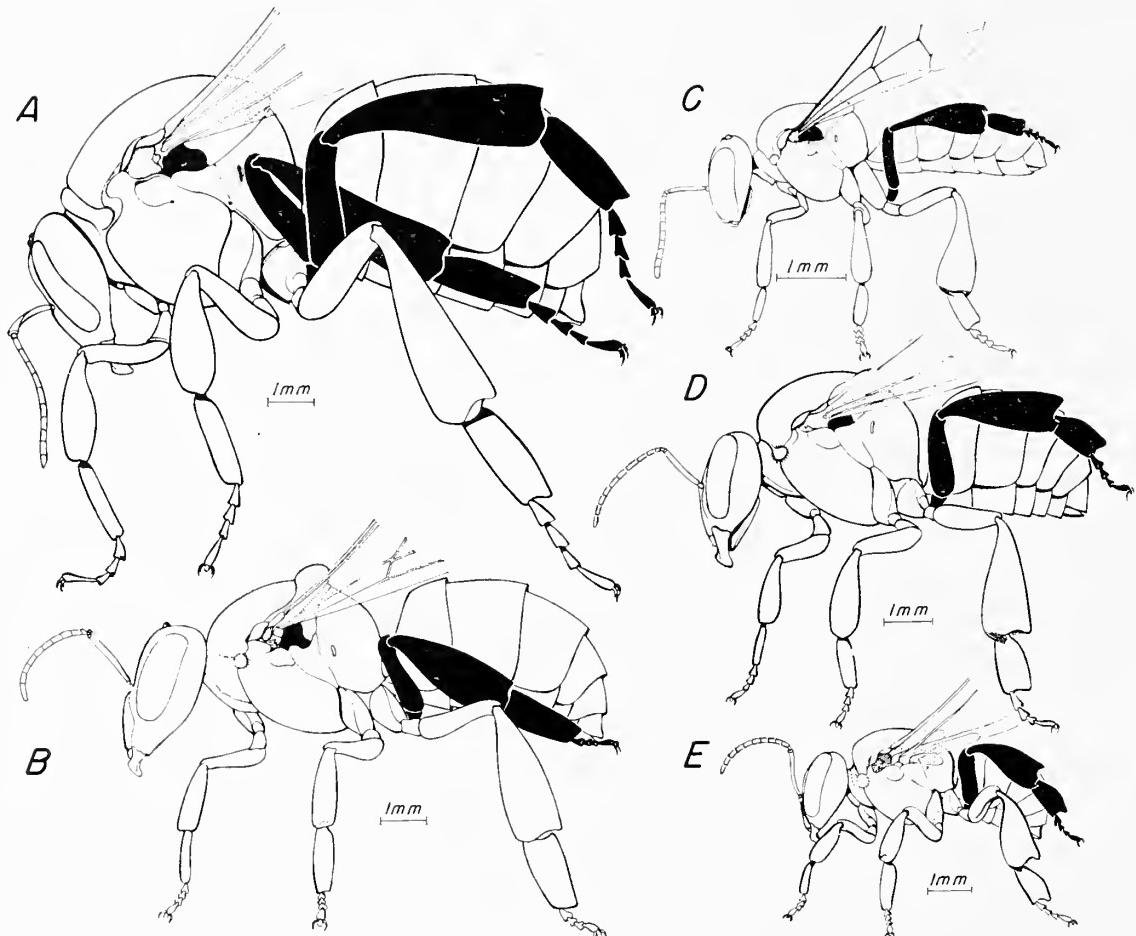


Fig. 7. Movements of hind legs for wax scale-removal: A. *Bombus*; B. *Apis*; C. *Trigona (F.) silvestrii*; D. *Melipona*; E. *Trigona (S.) postica*.

(1957) found in *Apis* that the secretion produced by the cells of mandibular glands has significance in working with wax, since the workers use the secretion to make the wax softer and easier to model. We found that the secretion of the mandibular glands of *Trigona (Oxytrigona) tataira* (Kerr and Cruz, 1961), and also *Melipona quadrifasciata* is capable of dissolving wax. In pre-

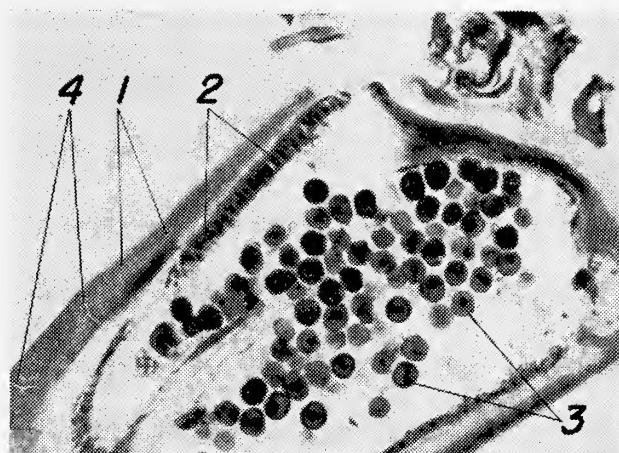


Fig. 8. Intramandibular gland of *Trigona (S.) postica* ♀: 1. Chitinous cuticle; 2. Glandular epithelium; 3. Oenocytes; 4. Intracuticular pores.

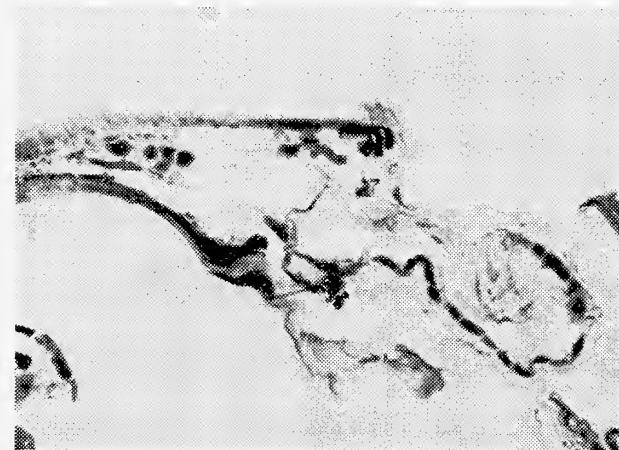


Fig. 9. Intramandibular gland of *Trigona (S.) postica* ♂.

paring histological sections of mandibles of *Melipona*, *Trigona*, and *Apis*, it was noticed that the workers of these bees have the intramandibular epithelium similar to that of the wax glands during the active period of secretion (Fig. 8). Oenocytes and fat cells within the mandibular glands also occurred. The chitinous cuticle which externally covers the mandibles has the pores filled with amorphous basophilic material, identical to that of the cuticle covering the wax glands of *Bombus*. In the queens of *Melipona* and *Trigona*, such epithelium, occurred though less

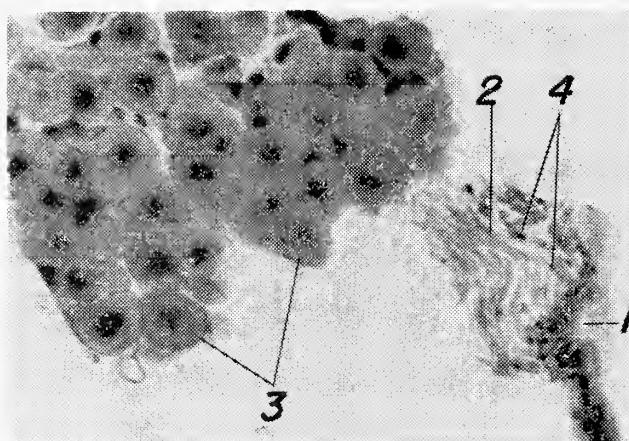


Fig. 10. Scent gland of *Melipona rufiventris* ♀: 1. Intracuticular end of excretory ductules; 2. Excretory ductule; 3. Scent cells; 4. Nuclei of ductules.

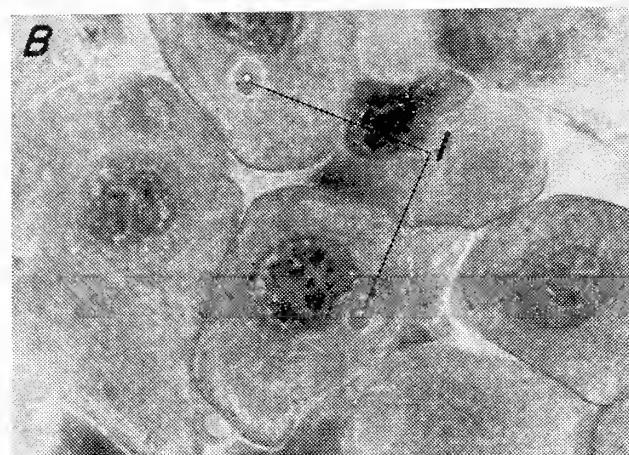
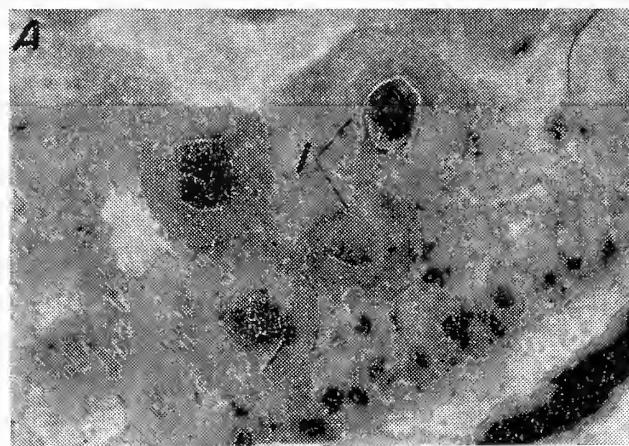


Fig. 11 (A and B). Scent gland of *Trigona postica* ♀ greatly magnified.
1. Intracellular portion of the ductule.

developed. The occurrence of glands could not be detected in drones of any species (Fig. 9).

It was assumed that glands other than mandibular glands were responsible for softening the wax. But, the finding of glands

within the mandibles similar to the wax glands suggested that these glands would be the source of the workers' wax solvent. This was tested by placing a small piece of wax on a slide. On one side of this wax there was arranged an extramandibular gland filled with secretion and on the other side an intact mandible. It was found that both glands have the capacity to soften wax since after a certain time they dissolved the surrounding wax.

SCENT GLANDS The scent gland is located in the anterior part of tergum VII in the area normally covered by tergum VI. Its structure in *Apis* was described by McIndoo (1914) and Jacobs (1924). According to them, this gland is composed of a group of cells, each provided with a delicate individual ductule, originating intracellularly at a space called an ampulla. The ductule is connected to the outside through a pore penetrating the chitinous cuticle.

Opinions of these two authors agree in admitting the absence of the scent gland in the drones of *Apis*, but disagree about its presence in the queens. McIndoo states it is present whereas Jacobs that it is absent. Since I could not find the gland in the *Apis mellifera ligustica* queen I am in accord with Jacobs.

In meliponids, the occurrence or absence of this gland in drones was not studied. It is absent in workers but well developed in queens with the location homologous to that in *Apis*. In general, no marked histological difference of the gland was observed between *Apis* and meliponids. It consisted of a group of more or less spherical cells, each provided with a chitinous ductule originating inside the cells. The ductule gives several turns within the cytoplasm around the nucleus before leaving the cell. Fig. 10. The cytoplasm around the ductule appears thicker and more stainable by hematoxylin. Fig. 11 & 12. Among the secretory cells of the scent gland can be found cells smaller in size. Each ductule is unicellular and is provided with a nucleus located laterally and immediately before its penetration to the cuticle. The presence of a scent gland was confirmed in workers of *Bombus* with no marked difference from species already mentioned.

CONCLUSION

Within the subfamily Apinae the wax gland appears even in

Euglossini, the unique non-social group but phyletically closely related to Bombini, which show a social organization in the most primitive state. In the latter the wax gland reaches greater development than in other species studied, and found in four segments both in dorsal and ventral sides. Whereas these glands develop only in the dorsal side in meliponids and the ventral side in *Apis*. This may be explained by secondary degeneration of either dorsal or ventral gland in these highly social groups, suggesting the primitive nature of *Bombus* in this aspect. The fact that the dorsal wax glands of *Bombus* are more developed than the ventral ones brings this genus closer to the meliponids than to *Apis*. The disappearance of the dorsal wax glands in *Apis*, and of the ventral ones in the meliponids corresponds to a specialization of these bees.

The fact that all castes of *Bombus* are able to produce wax (Wheeler, 1928) shows that the castes in this group are still not well differentiated. In the meliponids as seen above the queens retain the glands but seldom produce wax and drones of some species do not have wax glands. The maximum specialization is attained in *Apis* in which only workers possess functional glands.

The scent glands appear in workers and queens of *Bombus*, in workers of *Apis*, and in queens of meliponids. The secretion of these glands is odoriferous and in *Apis* serves to integrate each hive by the so-called colony specific odor.

In the meliponids this function is performed by the extra-mandibular gland which produces an odoriferous secretion. Hence, the disappearance of the scent gland in workers shows they took another direction in the evolution of the function concerned. The permanence of these glands in queens may be explained since this caste is always less specialized than the workers, for the queens sole role in the maintenance of the colony is as a unique reproductive agent. Studying the poison glands of the stingless bees, Kerr and de Lello (1962) also concluded that queens are more primitive than workers in this respect.

Acknowledgments

I am indebted to Dr. Warwick Kerr and Dr. Shôichi Sakagami for aid in the research and the preparation of this paper.

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**ANATOMY OF ADULT QUEEN AND WORKERS OF
ARMY ANTS *ECITON BURCHELLI* WESTW.
AND *E. HAMATUM* FABR. (HYMENOPTERA:
FORMICIDAE)**

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ABSTRACT

Forty-four queens (including five callows), several hundred workers of the polymorphic series, and males of the two species are studied, covering all systems but with particular attention to glandular cytology as between queens and workers. The post-pharyngeal gland of the queen fills most of the head cavity anterior to the brain; that of the worker is smaller but similar. Small glands at the bases of the legs contain increasing numbers of cells through the polymorphic series; most of all in the queen. The metasternal gland is conspicuous in the queen's thorax but not so in the worker's; the poison glands of the queen are larger than in the worker and present still other differences. The reproductive system of the queen is described in terms of differences in specimens collected at various points in the functional cycle of the colony, also in terms of differences between cal-low and functional queens and in contrast to the simple system of workers. Differences in the muscular, nervous and respiratory systems of queen and worker are described. In dorylines these last systems are similar to those in other ants except for secondary details related to physogastry in the queen. Included are 17 detailed plates.

INTRODUCTION

Many papers have been written on the anatomy of ants. In his book (Ants, 1926) Wheeler summarized the papers published before that date, and gave a complete bibliography of such papers. The relatively few papers on ant anatomy that have appeared since deal mainly with myrmicine and formicine ants. Ponerine ants have been less frequently described. Papers describing the anatomy of doryline ants have appeared infrequently.

In these papers, only a few consider the genus *Eciton*, and each of these limits itself to some particular structure. The earliest of these papers, that of Miss Holliday (1904), in scarcely more

than a single page gives a brief description of the gross features of the reproductive organs of the queen, and a statement that in workers no ovaries were found. The species described was *Eciton schmitti* Emery = *Neivamyrmex nigrescens* (Cresson). More recently, Marcus (1951, 1954) has published papers in which *Eciton* is treated rather briefly. He describes conditions in larvae and pupae, and suggests that early chitin formation may cause space limitations which prevent ovary formation in the worker castes, and discusses the functions of the corpora allata. He does not give much attention to the two species *Eciton burchelli* and *hamatum*.

Finally Hagan (1954) published a three-part paper describing and discussing the reproductive system of the army-ant queen (*Eciton burchelli* and *hamatum*), including also some notes on the structure of certain glands occurring in the gaster.

I am indebted to Dr. T. C. Schneirla of the Department of Animal Behavior, The American Museum of Natural History, for his cooperation with this study by furnishing for it large numbers of queens, males, and workers of *Eciton* species. These specimens were collected and preserved from colonies studied in field investigations by Dr. Schneirla on the behavior and biology of the army ants, supported through contracts with the Biology Branch, Office of Naval Research, and grants from the National Science Foundation. I wish, also, to thank Mr. G. W. Rettemeyer of the Department of Entomology, University of Kansas, for much supplementary material.

MATERIAL AND METHODS

In the present study, only adult material is considered. Included are forty-four queens (five of which were labeled "callow") and several hundred workers. These workers include about equal numbers of minor, medium, and major individuals, with somewhat smaller numbers of soldiers. Many of the workers (in all forms) were also labeled "callow." A small number of mature males were studied; these are mentioned rarely in this report.

The specimens studied were collected by Dr. Schneirla mainly in Panama and in Trinidad. An enumeration of specific items, in the case of queens and males, with a report on the behavior

and biological condition of the respective colonies prior to time of collection, will be found in Schneirla (1949), and in Schneirla and Brown (1950 and 1952).

For the most part, specimens were fixed shortly after capture. With some of the queens, however, laboratory study as live specimens delayed fixation by periods of from three to twenty-four hours. After fixation, all specimens were stored in a solution of 70% alcohol and 1% glycerine.

All material was fixed in a modification of Bouin's Picroformol fixative, changed at times to favor fixing of some particular structure. Fixation, in general, was satisfactory; poorer fixation occasionally occurred, possibly because the insects were kept under unnatural conditions for study prior to fixation. Material was prepared for study by being embedded, sometimes in celloidin, more frequently in paraffin. Dissections were also prepared. Staining was mainly with Heidenhaim's iron-alum-haematoxylin, occasionally with various counterstains.

ANATOMICAL DETAILS

Examination of a preparation of an *Eciton* queen, sectioned and stained for cytological study of cells in the reproductive system, showed many anatomical details that seemed unlike those recorded in other ants. This led to an extensive study of large numbers of specimens of the two species *Eciton burchelli* Westwood and *Eciton hamatum* Fabricius. This study included all stages: eggs, larvae on all instars, prepupae, pupae, and adults, with equal attention given to all castes of workers and queens. Smaller numbers of male larvae, pupae, and adults were also prepared.

BODY WALL

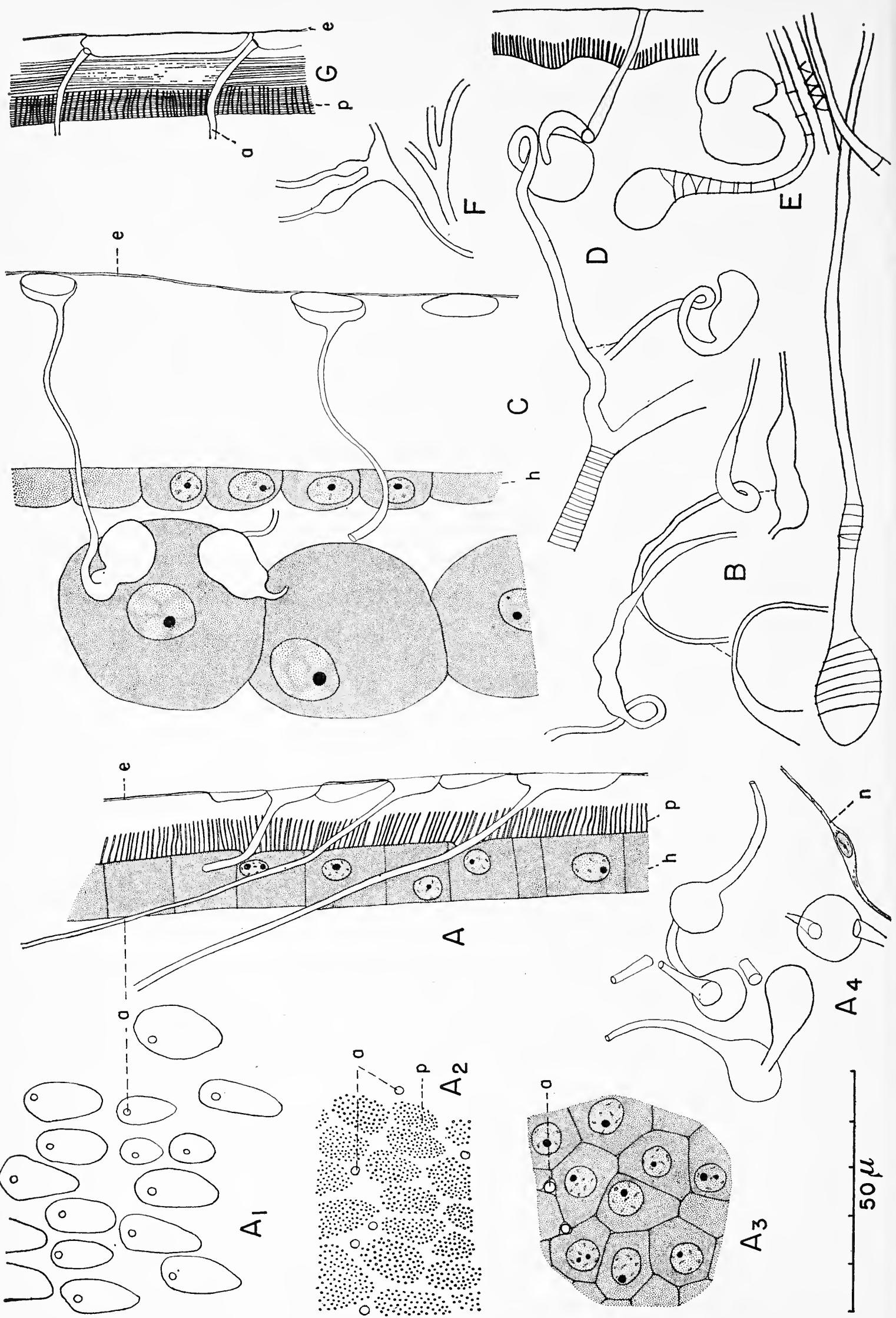
The body wall or exoskeleton of *Eciton* is neither unusually thick nor exceptionally hard, and may be easily cut into thin sections. Sections show clearly that there are two layers: the outer one (epicuticle) seldom less than one micron in thickness and the inner layer (cuticle) variable in both thickness and structure. The outer portion of this cuticle is homogeneous; the inner portion is characterized by the presence of large numbers of fine pores measuring 0.1–0.2 in diameter. The thickness of these two zones varies greatly; occasionally, the outer zone (exo-

cuticle) includes as much as two-thirds of the total thickness of the body wall; especially in the head and thorax, the inner zone (endocuticle) is thicker, in some cases equalling three-fourths of the total thickness. Characteristically, the endocuticle is stratified, the strata varying in thickness. The presence of the many fine pores obscures the lines of stratification, but does not hide them completely.

Examination of a series of thin sections cut parallel to the outer surface of the body wall, shows much outer surface to be characterized by a mass of irregularly elliptical depressions separated by narrow ridges (Fig. 1, A₁). Sections immediately beneath this surface are homogeneous, excepting certain small pores presently to be mentioned. In sections at a still lower level in the wall, numerous fine pores appear (Fig. 1, A₂). They occur in elliptical groups, separated by narrow lines free from these micropores; these pore-free regions correspond to the ridges seen on the surface.

The body wall is pierced by a number of conspicuous canals through which fine nerves pass to the bases of the numerous spines that occur on the surface. These nerve canals are often irregular, some enlarging to diameters three to four times that found at their lowest point, then narrowing abruptly just beneath the base of the hair. Other nerve-canals make abrupt turns, so great that the mid-portion of the canal is at right angles to the inner and outer portions.

A second type of opening through the body wall in these two species of *Eciton* are relatively slender pores 0.75 to 2.4 μ in diameter (a in Fig. 1, A and A₁₋₃). The unguarded external openings occur singly in the depressions in the outer surface of the wall. The course of the pore through the wall varies greatly; some pass straight through, in a course perpendicular to the surface; some equally straight, pass at an angle as much as 30° to the surface; and some curve gently or strongly (a in Fig. 1, A, C, G). Emerging from the inner surface of the cuticle, these pores continue as thin-walled tubes between the cells of the hypodermis and into the body cavity. Within the cavity the lengths and nature of these tubes vary from 30 μ long to 2 mm. By far the greatest number of them become irregularly curved or angled. Invariably each tube enlarges to form a conspicuous chamber varying in shape from nearly spherical through variously elongated to ir-



regular (Fig. 1, A₄, B, C, E). Occasionally, two or rarely three chambers occur along a single tube. The chambers in *E. burchelli* tend to be more broadly rounded than those of the slender and fusiform *E. hamatum* (Fig. 1, A₄ and B). Often the tubes divide into two or sometimes three branches (Fig. 1, F). These tubes end internally in one of three ways: some anastomose; some end blindly in a terminal bladder (Fig. 1, E); and some join to a small terminal branch of the tracheal system (Fig. 1, D). This last occurrence suggests that these tubes are accessory respiratory organs, and might be named aeration tubes. In the tracheal tubes numerous, usually annular, thickenings occur on the inner surface (Fig. 1, D); thickenings occur rather sparingly on the walls of the aeration tubes, but always on the outer surface (Fig. 1, E).

These aeration tubes occur in certain regions only. In the head they are found in the antenna rarely, in the mandibles; in the thorax they are limited to the posterior aspect of the epinotal horns and to the legs. In the latter they are abundant, especially in the tibia and tarsal joints. They are abundant in the posterior aspect of the petiolar horns of the queen. They also

Explanation of abbreviations: l.s.=longitudinal section; c.s.=cross section; t.s.=transverse section; s.s.=sagittal section; tg.s.=tangential section.

FIG. 1. Body wall and related structures.

- A l.s. of leg wall, *E. burchelli*
- A₁ Outer surface of leg with elliptical depressions, each with opening of an aeration pore (a)
- A₂ Inner surface of body wall showing groups of micropores (p) and aeration tubes (a)
- A₃ Hypodermis with aeration tubes (a)
- A₄ Leg beneath hypodermis with aeration tubes and chambers, fine nerve (n)
- B Leg of *E. hamatum*, cf A₄
- C l.s. pedicel wall, *E. burchelli* queen, left to right: oenocytes, aeration tubes and chambers, hypodermis (h), cuticle and epicuticle (e)
- D Tibia wall, *E. burchelli* queen, aeration tube extends from chamber, fuses with tracheal branch
- E Aeration tubes and chambers, *E. burchelli*
- F Tibia *E. hamatum*, branching aeration tubes
- G l.s. gaster wall, posterior-lateral region, aeration tubes (a), micropores (p), stratified endocuticle and epicuticle (e)

are found in the posterior segments of the gaster, where they are abundant only in the queen.

Excepting the areas where muscles have their origin and insertion, the hypodermis forms a continuous layer beneath the cuticle. The cells of this hypodermis are mainly prismoidal, varying considerably in thickness in different areas, but remaining constant in any one area (h in Fig. 1, A, C). The one area which is not constant is under the intersegmental membranes of the gaster of the queen. In virgin queens, the hypodermal cells are much like those under the cuticle of adjoining areas. With the advent of physogastry the intersegmental membranes are stretched greatly; as well as the cells of the hypodermis beneath the membranes, until they become little more than somewhat flattened nuclei held in an extremely thin layer of cytoplasm. When contraction follows an egg-laying period, instead of the membrane contracting elastically, it is thrown into a series of deep folds against which the hypodermal cells remain. In limited areas the cells become long, columnar, and often curved. Conspicuous among these are areas in the extreme posterior region of the gaster. (Fig. 8, D)

Lying beneath the hypodermis and somewhat removed from it are the oenocytes and the fat-cells. In callow individuals, both queens and workers, the oenocytes are so numerous that they form an almost continuous layer in many parts of the body, being conspicuous in several segments of the legs and in the gaster. These oenocytes are large and vary in shape from nearly spherical to broadly ellipsoidal or even slightly irregular. Each contains a single spherical nucleus. The chambers of the aeration tubes often occur in contact with an oenocyte, sometimes enough to form a depressed area in the side of the oenocyte.

Neither the muscles, the nervous system, nor the respiratory system of *Eciton* needs detailed description, being similar to the corresponding system described in other ants.

Upon comparing a muscle of *Eciton* with the corresponding muscle in *Myrmica* or any other ant and with the same muscles occurring in the several forms of *Eciton* the most obvious difference in the muscle is that of size. In large workers and soldiers the abductor muscle of the mandible is a very large muscle, its origin covering a large part of the posterior-lateral margin of the wall of the head, and narrowing gradually to its insertion on

a prominent tendon that passes into the base of the mandible. In the medium worker, this muscle is much smaller than in the larger forms: in the smallest workers it is a small muscle, much smaller than is indicated by the comparative sizes of the heads. In the much larger queen this muscle, while large in comparison with that of the medium and small workers, is small and weak-looking in comparison with the muscle of the larger workers.

More noticeable is the difference between the sizes of the complex of muscles motivating the sting, which are conspicuously small in the queen, since the gaster has no room for large sting muscles.

In all forms, the ambulatory muscles of the thorax are large, the apodemes to which they are attached being noticeably so. There is no trace of flight muscles in the queens.

THE NERVOUS SYSTEM

There is great variation in the preservation of this system, especially noticeable in the queens. While preservation is excellent in many of the specimens, there are many in which it is decidedly indifferent. Because of this, it seems unwise to attempt comparisons which call for exact dimensions, especially of the brains. The approximate widths of the brains average as follows: minor workers $310\ \mu$, medium workers $380\ \mu$, major workers $450\ \mu$, soldiers $600\ \mu$, queens $850\ \mu$, and males $450\ \mu$. Several large nerves are conspicuous features of the head. The largest of these pass into the antennae and into the mandibles. In the queen, the most conspicuous nerve from the brain is the optic nerve, from 45 to $60\ \mu$ in diameter. The length of this nerve varies greatly. It may extend about half the distance from its point of exit from the brain to the body wall, or about $900\ \mu$, the nerve thus ending about $100\ \mu$ from the cuticle. The distal part of this nerve narrows gradually to about one-half its maximum diameter at its other end.

The cortical tissue of the brain varies considerably in thickness in any given area. In old specimens of *Eciton*, it becomes very thin. The cells of the cortex are uniform in size, averaging $3-5\ \mu$ in diameter; rarely do larger cells occur, the largest measured being $19\ \mu$ long and $12\ \mu$ in diameter.

In the thorax, only the last of the three ganglia need be described. In the posterior thoracic ganglion, the medulla in the

workers is separated into two distinct masses, in the queens into three, the posterior medullary mass being smaller than those before it. A small ganglion occurs in the petiole and the post-petiole of the worker and in the petiole of the queen.

The gastric ganglia of the queens are unlike those found in the workers. In the queen five large ganglia are found, the last of which has a medulla, apparently formed of two or sometimes three masses. This posterior ganglion occurs below the common oviduct, usually near its anterior end. The commissures connecting it to the ganglion before it are longer than those joining any of the other pairs of gastric ganglia.

In the workers, large and small, the entire chain of gastric ganglia is condensed into a mass of uniform diameter, occurring in the anterior half of the first, large gastric segment, its posterior end usually below the anterior half of the stomach. Longitudinal sections of this compound ganglion show the separate medullary masses of the ganglia. The nerves extending from this ganglion chain are extremely slender; those from the posterior end usually appear as straight fine lines extending back to the tissues in the posterior part of the gaster.

The corpora allata are small ovoid bodies occurring under the posterior portion of the brain. Their dimensions vary, from 50–70 μ in length and from 30–80 μ in diameter. Some are nearly spherical, others twice as long as their greatest diameter. They usually contain 10 or 12 nuclei, measuring 7–9 μ by 10–12 μ which are uniformly spaced in the body.

In the queen the walls of the large, irregular trachea of the gaster vary considerably during the change from completely contracted individuals to those fully physogastric. These walls appear non-elastic, though flexible. This results in the occurrence of a complex type of folding of the walls of the larger tracheal tubes when the gaster is contracted. There is also a certain increase in diameter of the main tracheal trunk in the gaster when physogastry begins. Maximum diameter is reached well before physogastry is advanced, when presumably maximum division and early growth of the cells of the ovarioles occur. As peak physogastry is approached, the diameter of the tracheal trunk decreases noticeably and remains fairly constant for the duration of maximum gaster size.

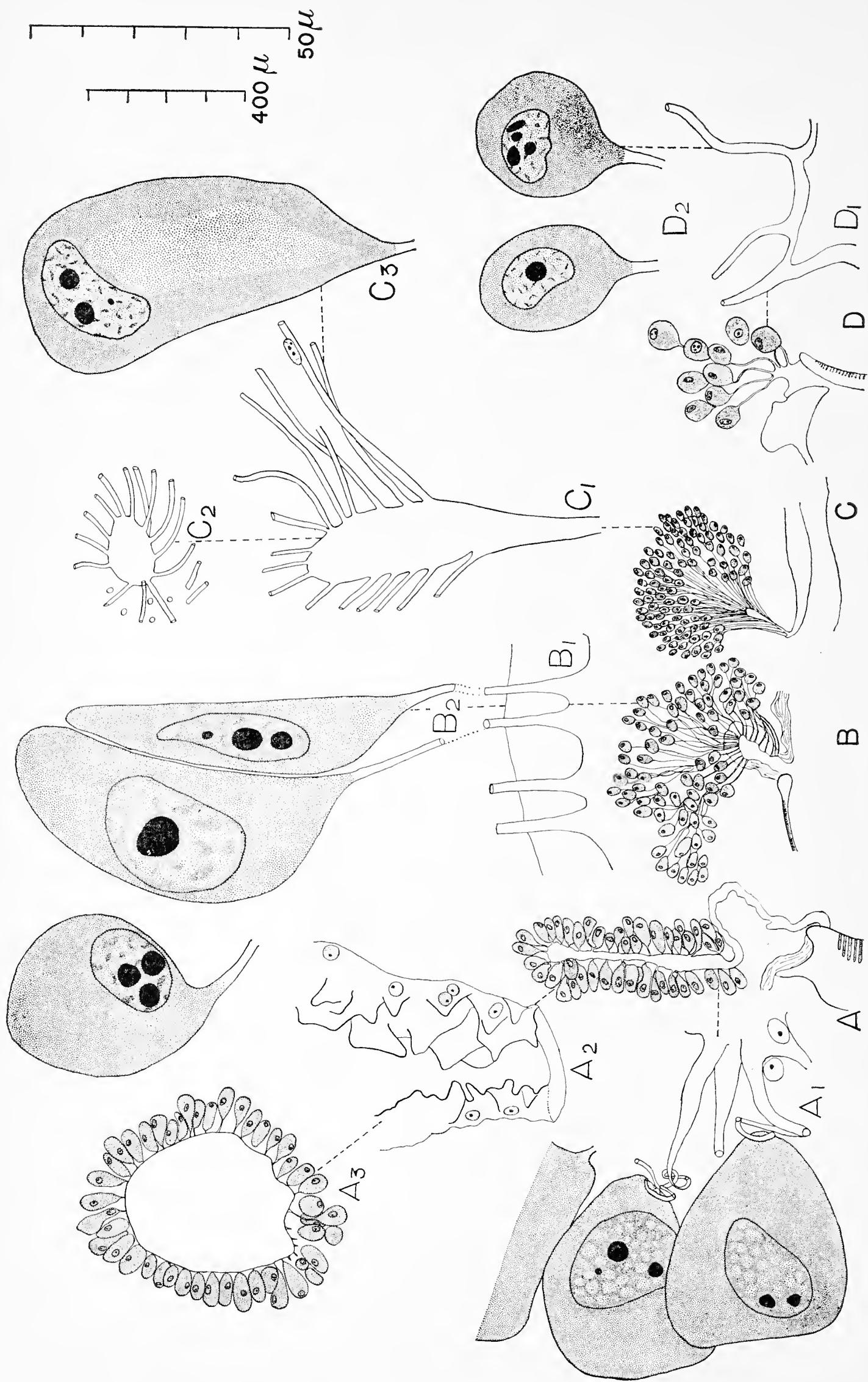
THE DIGESTIVE SYSTEM AND RELATED STRUCTURES

The mandibles, whether they are the broadly triangular coarsely toothed ones of the workers or the curiously long hooked ones of the soldiers consist of five tissues. These are the hypodermis, which forms a thin continuous layer against the inner surface of the membrane joining the cuticle of the head and that of the mandible; a small tracheal branch; the tendons of the mandibular muscles, which are inserted on the walls of the mandible near its base; the large nerve which extends to the apex of the mandible, giving off numerous slender branches to the many hairs occurring on the surface of the mandibles; and the anterior end of the chamber of the mandibular gland (Fig. 2, A).

In all forms of the two species of *Eciton* considered here, the mandibular gland has a structure so characteristic that even small bits are easily recognized. In shape and in size, there is much variation, especially in the chamber. Typically it is elongate, irregular object narrowing gradually as it nears the base of the mandible. Passing into the mandible, it turns abruptly outward to end in a small elliptical pore through the thick wall of the mandible. These elongated forms measure about 1000 by 160 μ in queens, 530 by 70 μ in soldiers, and 200 by 48 μ in small workers. Measurements may however, be misleading, for in any single form this gland chamber may be about 350 μ long, with the maximum diameter varying from 75 to 320 μ . This maximum may be found near the apex, near the middle, or in rare cases near the base or anterior end, not far from that point where it narrows to pass into the mandible. Conceivably the gland may change considerably in size and in shape as the secretions of the cells accumulate or are used. In extreme cases the main part of the gland chamber may be nearly spherical, and about 300 μ in diameter. While this spherical shape may occur in all worker forms, it occurs most often in the minor workers.

This gland characteristically varies in the anterior portion of the chamber, where it usually becomes a narrow tube. This is seldom a straight tube; the most common variant is one having two abrupt turns of about 90°; in some cases the turns are so extreme the narrow portion shows three nearly parallel sections.

In the males, the posterior end of this gland is frequently bifurcate, the two short coarse branches passing one above, the



other below the large optic nerve. Occasionally the gland is deflected sharply to pass either above or below this nerve.

The ducts of the many secretory cells open into the chamber of the mandibular gland. These openings often occur singly and are evenly spaced. Occasionally, in the queens and largest workers, the openings of several ducts occur so closely, a conspicuous conical evagination of the chamber wall is formed.

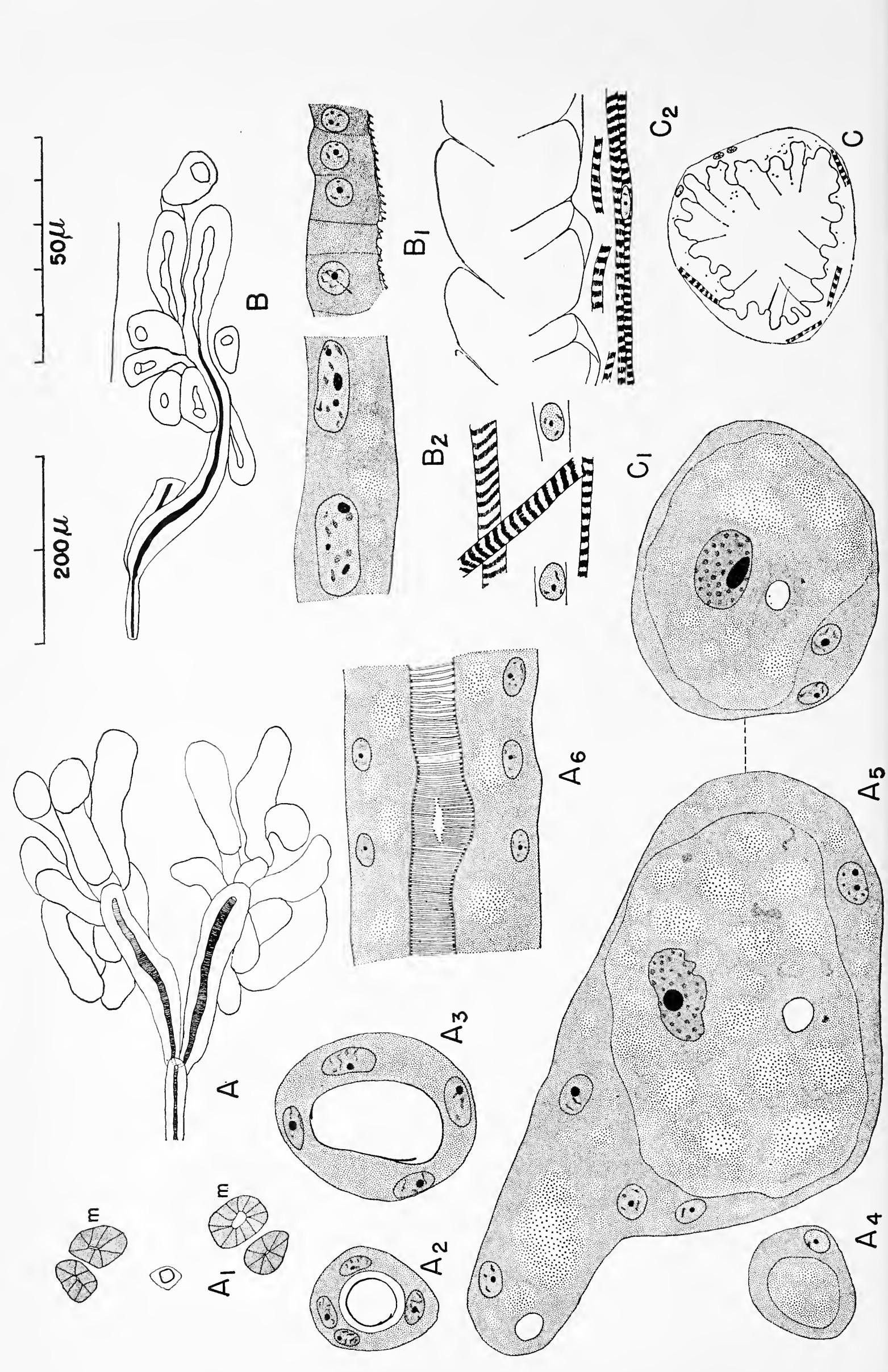
The ducts of this gland are 20–65 μ in length, scarcely 1–2 μ in diameter at the apex and gradually increasing to a diameter of 4–6 before enlarging abruptly as they open into the chamber. At the upper end, each duct is usually irregularly coiled, another indication that emptying of the chamber causes adjustment of the ducts opening thereinto (Fig. 2, A₁).

The secretory cells vary greatly in size and in shape; a long narrow one may measure 85 by 28 μ ; a short broad one, 43 by 38 μ . Some are spherical, some pyramidal, and many irregular. The single nucleus in each cell may vary from spherical to irregularly flat (Fig. 2, A₁). The number of secretory cells in a gland varies from a minimum of 100 to a maximum over 1400.

Extending from the mandibles to the bases of the mouth parts and around them, is a membrane in which the openings of the ducts of three glands are found. The first of these is a small gland comprising three or four to twenty or more cells and their ducts; the latter open near the base of the mandible. The sec-

FIG. 2. Glands in head (anterior).

- A Mandibular gland of major, *E. burchelli*, wall of mandible at base, chamber and cells of gland
 - A₁ Cells and ducts of medium worker
 - A₂ Wall of chamber of gland, below secretory portion, showing nuclei
 - A₃ t.s. of secretory portion
 - B "Intermediate" gland, between mandible and mouth parts
 - B₁ Duct openings
 - B₂ Secretory cells in a major of *E. burchelli*
 - C Maxillary gland of *E. burchelli* queen
 - C₁ "Chamber" of gland, with ends of ducts
 - C₂ t.s. of chamber
 - C₃ Secretory cell of gland
 - D Gland at tongue base of medium worker
 - D₁ Duct openings of gland
 - D₂ Secretory cells
- Scale: A, B, C, D—50 μ scale, other parts—400 μ scale



ond gland is large and its secretory cells number 30–50 in the smaller worker forms and about 300 in the queens (Fig. 2, B). Exact counting is difficult, since the cells of this gland and those of the maxillary gland occur in a confused group with no region of separation; only by tracing the ducts can one determine to which gland the cell belongs. These ducts vary greatly in length; those of the cells nearest the membrane may be as short as 8 μ , while some of the remote cells have ducts over 30 μ long. Transition from the base of the cell to the duct is usually gradual, with the diameter of the ducts a fairly constant 2–3 μ (Fig. 2, B₂). Some of these ducts open singly through the membrane (Fig. 2, B₁), while many form compact groups opening through the walls of a conical invagination of a part of the membrane. The secretory cells of this gland have the same nuclear variation and size and shape range as was noted in the cells of mandibular glands. The third gland, occurring at the base of the mouth parts, is a small one, the total number of its cells is seldom more than fifteen to twenty (Fig. 2, D, D₁, D₂). The cells are smaller than those found in the previous glands, and of uniform broadly oval shape averaging 28–30 μ by 22–24 μ . The ducts of this gland are much shorter than those found in the other glands rarely measuring more than 4–7 μ .

FIG. 3. The salivary gland and oesophagus.

- A Salivary gland, showing ducts and secretory branches in thorax
 - A₁ t.s. duct in tongue, near opening, with muscles (m) to palps
 - A₂ t.s. of duct posterior to tongue
 - A₃ t.s. of duct below brain
 - A₄ Secretory portion, near apex of branch in worker
 - A₅ Secretory portion in queen
 - A₆ l.s. of duct in thorax, prior to duct merger from opposite side
 - B l.s. of one side of secretory portion and ducts of salivary gland in thorax of worker minor
 - B₁ Dorsal wall of duct, near secretory portion, with large nuclei
 - B₂ As above with small nuclei
 - C Oesophagus, t.s., in mid-thorax *E. burchelli*, showing muscles and spines
 - C₁ l.s. of outer part of oesophagus showing irregular musculature
 - C₂ l.s. of oesophagus, showing muscles and wall, with spines of upper and lower surface of wall
- Scale: A and B—200 μ scale; others 50 μ scale

Detailed examination of the mouth parts was not made in this study. The several muscles found in them, even though small, are more robust in *Ectiton* than in many other ants, and have prominent striations. Of greater interest is the salivary (labial) gland (Fig. 3), the duct of which opens at the base of the tongue. This opening may be a transversely elongated slit or broadly elliptical; the relative position of the tongue determining the shape of the opening. When circular, the opening is $3\ \mu$ in diameter in small workers and $5-6\ \mu$ in the queens (Fig. 3, A₁).

The duct of the salivary gland as it leaves the base of the tongue is about $4-5\ \mu$ in diameter in the several forms, with the lumen $0.5\ \mu$ in diameter (Fig. 3, A₂). The inner wall bears evenly spaced low annular thickenings. As it passes posteriorly through the head (Fig. 3, A₃) and into the anterior thorax, the duct gradually enlarges to $35\ \mu$ in diameter, with its central lumen increasing to $18\ \mu$. At the same time the discoid nuclei occurring in the wall of the duct increase from $4-5$ by $2.5-3\ \mu$ to 11 by $4.5-5\ \mu$. Passing through the head, this duct may pass down nearly to the lower wall of the head or it may be almost in contact with the brain.

Passing into the thorax, the diameter of the duct continues to increase to $40-50\ \mu$, with the central lumen tending to decrease to $14-16\ \mu$ and to vary from one point to another (Fig. 3, A₆). Presently the duct divides into two equally large, thick-walled branches which gradually separate to opposite sides of the anterior thorax (Fig. 3, A). There it gives rise to several short, thick, irregular branches which are the secretory part of this gland (Fig. 3, B). In the queens, the total length of this part of the gland is $1.5-3$ mm.; in small workers, about 0.5 mm. The diameters of these branches vary from 55 to $80\ \mu$, in a single queen, with the central lumen about $6\ \mu$ in diameter. In this portion, there are many large nuclei of irregular shape measuring 32 by $10\ \mu$. Peripherally there are many small, usually spherical nuclei $5-7\ \mu$ in diameter (Fig. 3, A₅). Membranes separating this secretory portion of the gland into cells can only rarely be discerned.

In the various worker forms, the salivary gland is smaller in every dimension, but has about the same appearance (Fig. 3, A₄).

Just above the bases of the mouth parts, the opening into the infrabuccal pocket is found. In all the queens examined, the

walls of this pocket are collapsed so that practically no cavity remains. Nor was there any sign of any content therein. The inner surface is characterized by a reticulation of shallow grooves. Over much of the inner surface of the pocket, the elevated areas formed by the grooves are smooth. But in a small area of the ventral surface, near the entrance to the pocket, the posterior part of each elevation is usually armed with a row of 8–12 short acute spines.

In the workers the infrabuccal pocket is always tumid, with the entire inner surface covered with closely set rounded bosses, the upper part of which bears many slender bristles. In nearly all individuals, from minor workers to soldiers, the pocket is filled either completed or partially with a mass of small particles. In these masses, insect material including joints of legs and pieces of antennae is frequent and easily identified as such; bits of animal material other than insect can occasionally be recognized; vegetable material occurs infrequently. This material is usually a loose mass; rarely pressed into a compact mass identified as a pellet, perhaps ready to be ejected.

Above and close to the entrance to the infrabuccal pocket is the mouth. This is always a transversely elongated opening, the margin of which is armed with a mass of thickly set stout, curved spines. Similar spines are found for a short distance into the mouth cavity. The transition from this buccal tube to the pharynx is not sharp and it is sometimes difficult to decide just where the change occurs.

From each lateral margin of the buccal tube, at approximately the junction to the pharynx, a slender diverticulum extends backward and inward somewhat above the infrabuccal pocket (Fig. 2, C). This diverticulum in the queens may be cylindrical or, more frequently, club-shaped; in workers it is usually a slender conical object. In both queens and workers, its shape is usually obscured by the occurrence of many small irregular diverticula from its surface. The total length may be 100–120 μ in queens, but shorter in the workers; its diameter is usually 15–20 μ in queens, less in workers.

Through the walls of these diverticula, the ducts of the cells of the maxillary glands open. In some individuals the duct openings occur irregularly over the entire surface; in others, and especially in the queens, two to many ducts may open so closely

together that their union forms a secondary diverticulum from the main one. Often these secondary diverticula are so numerous that the main one appears to be irregular, and repeatedly branched.

The ducts are uniformly slender, seldom as much as 1μ in diameter and variable in length, the shortest being those going to cells located near the wall of the diverticulum, the longest up to 40μ long to reach cells near the margin of the gland.

The total number of cells in each of the paired glands varies from 200 to 320 in the queens, many less in the workers. Some are elongate, some nearly spherical, and many irregular. Samples of dimensions are 80 by 22μ , 65 by 60μ , 50 by 50μ , 60 by 45μ in queens; 27 by 17μ to 25 by 22μ in workers. In nearly all individuals the cells are closely aggregated and it is often difficult to find any line of separation between the two glands. Furthermore, they are in no way distinct from those of previously described glands. Often there appears to be a single compact gland extending from the base of one mandible all the way across the front of the head to the base of the other mandible.

(To be continued)

DEFORMITIES OF EXTERNAL GENITALIA IN SPIDERS

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ABSTRACT

Brief descriptions are given of 14 cases in which the epigynum or the palpus is deformed. It is suggested that for the most part these stem from accidents during the molting process, or to imperfect regeneration of a part lost between molts.

Ordinarily one may expect to find abnormalities of the genitalia in spiders that are gynandromorphs or intersexes, and cases of these latter have been summarized by Kaston (1961). Also, there have been a few cases of duplication of the epigynum

(Kaston, in press). The present report deals with cases that do not fall within the above categories, *i.e.*, they are not gynandromorphs or intersexes, nor do they exhibit duplication of the epigynum. Thanks are due Dr. W. J. Gertsch of the American Museum of Natural History, Dr. H. W. Levi of the Museum of Comparative Zoology at Harvard, Dr. H. K. Wallace of the University of Florida, and Dr. Harriet E. Frizzell, for the loan of specimens in their care. The illustrations were all prepared by my wife.

DESCRIPTION OF CASES

No. 1 *Pardosa fuscula* (Thorell)

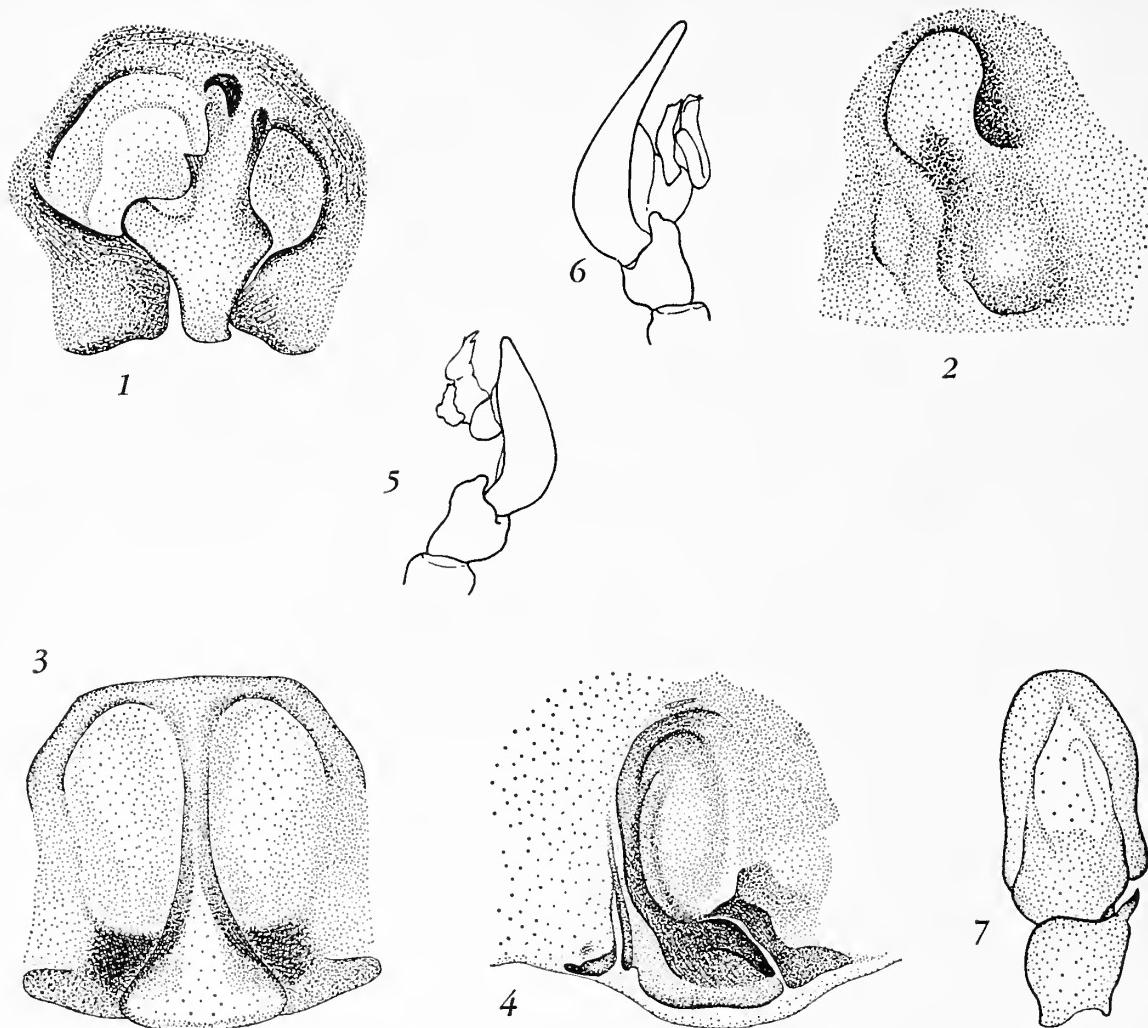
The spider was collected at Medicine Hat, Alberta, Canada in August 1930. The specimen is normal except for the epigynum, which is quite asymmetrical (figure 1). It differs from the normal in being wider; in having the guide shorter and with its median longitudinal portion wider; in having the transverse part of the guide extending much farther to the right than to the left; and in having the right alveolar space much larger than the normal, while that on the left is much smaller.

No. 2 *Metaphidippus galathea* (Walckenaer)

The spider was collected at Wilmington, North Carolina by D. L. Wray on March 15, 1939. The specimen appears normal except for the epigynum. As can be seen from figure 2, the left side is normally developed, but the right side is reduced both as to size of the structures themselves and as to the degree of pigmentation. This, of course, produces an asymmetry, and in fact the appearance resembles those epigyna in which only one half develops properly because of lateral gynandromorphism (Kaston 1961).

No. 3 *Geolycosa patellonigra* Wallace

The specimen was collected in Marion County, Florida by H. K. Wallace on May 31, 1940 and is included in the paratype material. It is normal except for the epigynum (figure 4). By comparing with a normal epigynum (figure 3) one can see that in this abnormal specimen most of the structures belong to the left half, the right half being very poorly developed. The left edge of the guide and the posterolateral extension toward the left side are more strongly sclerotized than is normal.



1. *Pardose fuscula*, deformed epigynum.
2. *Metaphidippus galathea*, deformed epigynum.
3. *Geolycosa patellonigra*, epigynum of normal specimen.
4. Same species, epigynum of abnormal specimen, at same scale.
5. *Agelenopsis pennsylvanica*, deformed left palp, ectal aspect.
6. Normal right palp of the same specimen, at the same scale.
7. *Paraphidippus* sp., ventral aspect of deformed right palp.

No. 4 *Agelenopsis pennsylvanica* (C. L. Koch)

The spider was collected at Jeffersonville, Indiana by H. Spieth on August 21, 1940. The right palp is normal. On the left palp the proximal segments, including the tibia, likewise appear normal. However, the length of the cymbium is only about two-thirds that of the normal one, as can be seen by comparing figures 5 and 6. Furthermore, the palpal organ itself is reduced, there being no sign of the spiral embolus so characteristic of this group of spiders, and the conductor is quite small.

No. 5 *Paraphidippus* sp. (probably *marginatus* Walckenaer)

This specimen was taken at Waco, Texas by M. Kegan. The two palpi are similar in appearance. Each shows a normal appearing tibial apophysis, and an enlarged cymbium. On the ventral side of the cymbium is a lighter area with well defined lateral edges. This area marks the usual site of the alveolar cavity, but no cavity is present, and of course there is no sign of a palpal organ (figure 7).

No. 6 *Phidippus clarus* Keyserling

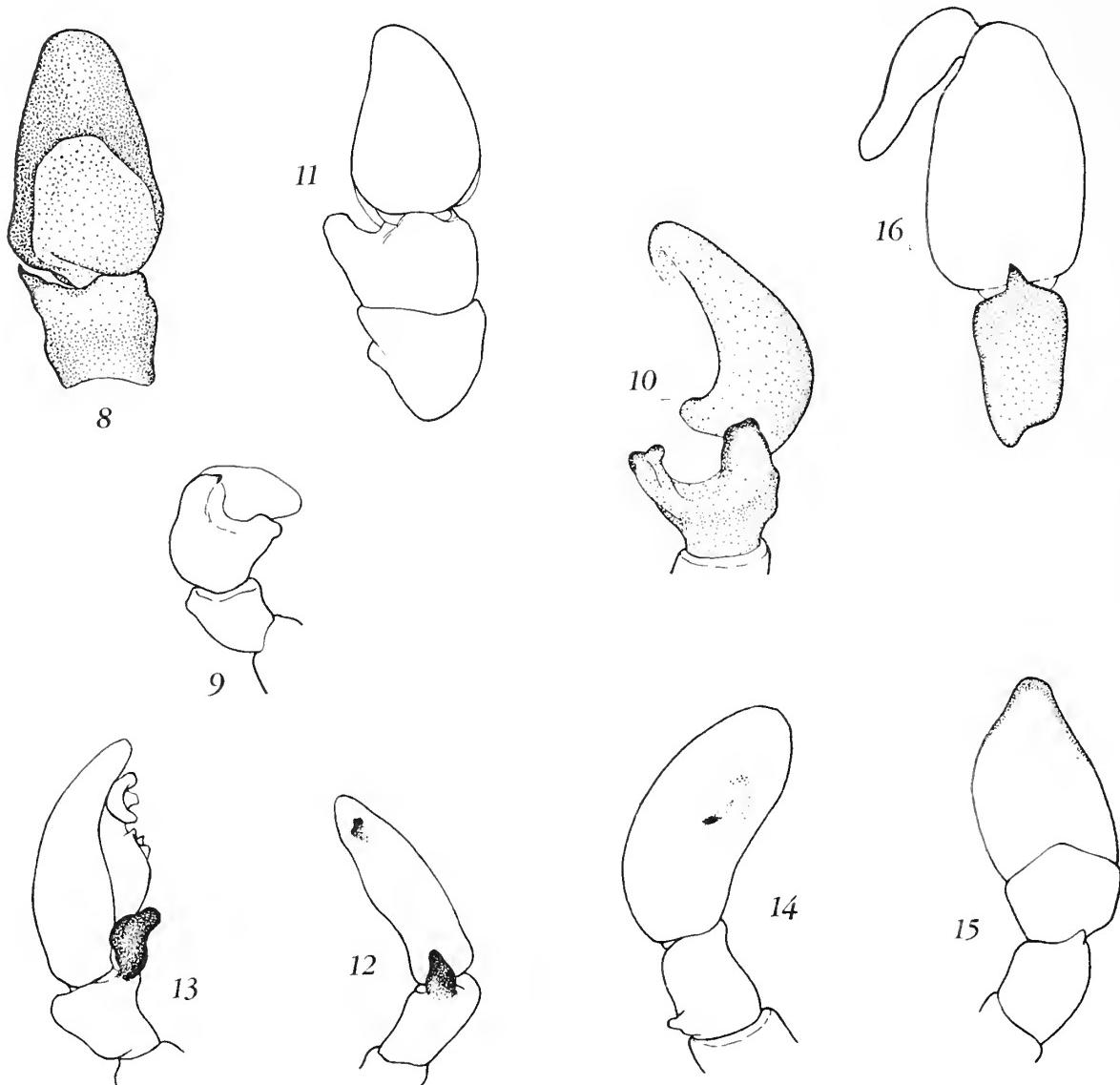
The spider was collected in Ontario, Canada by T. B. Kurata on June 7, 1938. The left palp is normal. The right palp shows a well developed tibial apophysis, and enlarged cymbium. But as in the preceding case (no. 5) there is no alveolar cavity and no palpal organ. Instead, there is a lighter area with distinct edges indicating where the alveolus would be if the palp were a normal one (figure 8).

No. 7 *Xysticus transversatus* (Walckenaer)

The spider was collected at Lambertville, New Jersey by Wilton Ivie in June 1952. The left palp is normal. The right palp has a tibia of about the same size as that of the left, but with the apophysis slightly different as illustrated (compare figures 9 and 10). The tarsal segment is considerably reduced, being very much smaller than that on the normal palp, and even smaller than the tibia. It shows no sign of the usual cymbial form, and is completely lacking the alveolar cavity. In contrast to the situation in cases 5 and 6 above there is not even an indication of where the alveolus would be.

No. 8

Another specimen of the same species (as in no. 7) was collected at Branford, Connecticut by the writer on June 22, 1937. The right palp is normal. The left palp has the proximal segments normal, but the tibia is somewhat shorter than normal with the apophysis reduced in size. The length of the cymbium is only about half that of the normal one. The alveolar cavity and palpal organ are completely lacking (figure 11). As in case no. 7 there is no indication of where the alveolar cavity margin would be.



8. *Phidippus clarus*, ventral aspect of deformed right palp.
9. *Xysticus transversatus*, case no. 7, ectal aspect of deformed right palp.
10. Ectal aspect of the normal left palp of the same specimen for comparison.
11. *Xysticus transversatus*, case no. 8, deformed left palp, from below.
12. *Corinna* sp., deformed left palp, ectal aspect.
13. Normal right palp of the same specimen, for comparison.
14. *Dictyna artemisia*, ental aspect of deformed left palp.
15. *Ceraticelus* sp., ental aspect of deformed right palp.
16. Same specimen, ectal aspect of the deformed left palp.

No. 9 *Corinna* sp.

This spider was collected in the West Indies (no other data available). The right palp appears normal (figure 13). On the left palp the tibia is not as widely expanded distally, and shows an apophysis which is not nearly so strongly developed as the normal one on the right palp (figure 12). The tarsus is shorter

than, and only half as wide as, the normal one. It has the same appearance that one notes on a tarsus in the penultimate instar, without the cymbium form or alveolar cavity. Near its distal extremity is a darker area, presumably an indication of parts of the developing palpal organ within.

No. 10 *Dictyna artemisia* Ivie

The specimen was collected at East Canyon of the Wasatch Mountains, Utah by Wilton Ivie on June 14, 1942. Both palpi are alike. A short tibial apophysis is present on each, but the tarsus is not developed as a cymbium nor is there a palpal organ. Near the middle of the tarsus one can make out a darker area, which, as in the preceding case (no. 9) is presumably an indication of the developing palpal organ within (figure 14).

No. 11 *Ceraticelus* sp.?

The spider was collected at West Ossipee, New Hampshire by S. B. Mulaik in August 1936. It has a body length of 1.25 mm., and seems to be a lophocarenine micryphantid probably in the genus *Ceraticelus*. Both palpi are deformed. In the case of the right one (figure 15) the tibia bears a very short apophysis, and the cymbium is devoid of a paracymbium. There is no alveolar cavity and no palpal organ. The tibia and the cymbium are white and hardly at all sclerotized, except for the distal tip of the latter. The cymbium itself appears divided by a transverse suture into a basal third and a distal two thirds. The left palp (figure 16) has a tibia that appears normal with respect to pigmentation and sclerotization, and has a distinct tibial apophysis. The cymbium, however, is white, not sclerotized, somewhat longer than the one on the right palp, and while it shows no paracymbium or alveolar cavity it does have attached to its distal end a peculiar extension. In other words, both palps show what might be considered a two-segmented cymbium, but with the distal segment being larger on the right palp, and smaller on the left.

No. 12 *Pardosa californica* Keyserling

This specimen was collected in Monterey County, California in May 1940. Both palpi are deformed. The left palp (figure 17) has the palpal organ protruding from the alveolar cavity as

a short cylinder. On the right palp the palpal organ is likewise extended but the cylinder is much longer and smaller in diameter (figure 18). Moreover, the distal end of the cymbium is bent sharply at a right angle, instead of being gently curved as on the left side.

No. 13 *Lycosa ammophila* Wallace

The spider was collected in Pasco County, Florida by H. K. Wallace on March 21, 1947. Both palpi are deformed. The right palp shows what appears to be an almost normal palpal organ, but the cymbium is transversely folded, and the distal third is bent dorsally as indicated in figure 19. The left cymbium is likewise transversely furrowed (figure 20) but is not bent dorsally. In addition, it is narrower and shows a considerable reduction in the development of the palpal organ itself, especially at the distal portion (figure 21). The embolus and conductor are lacking.

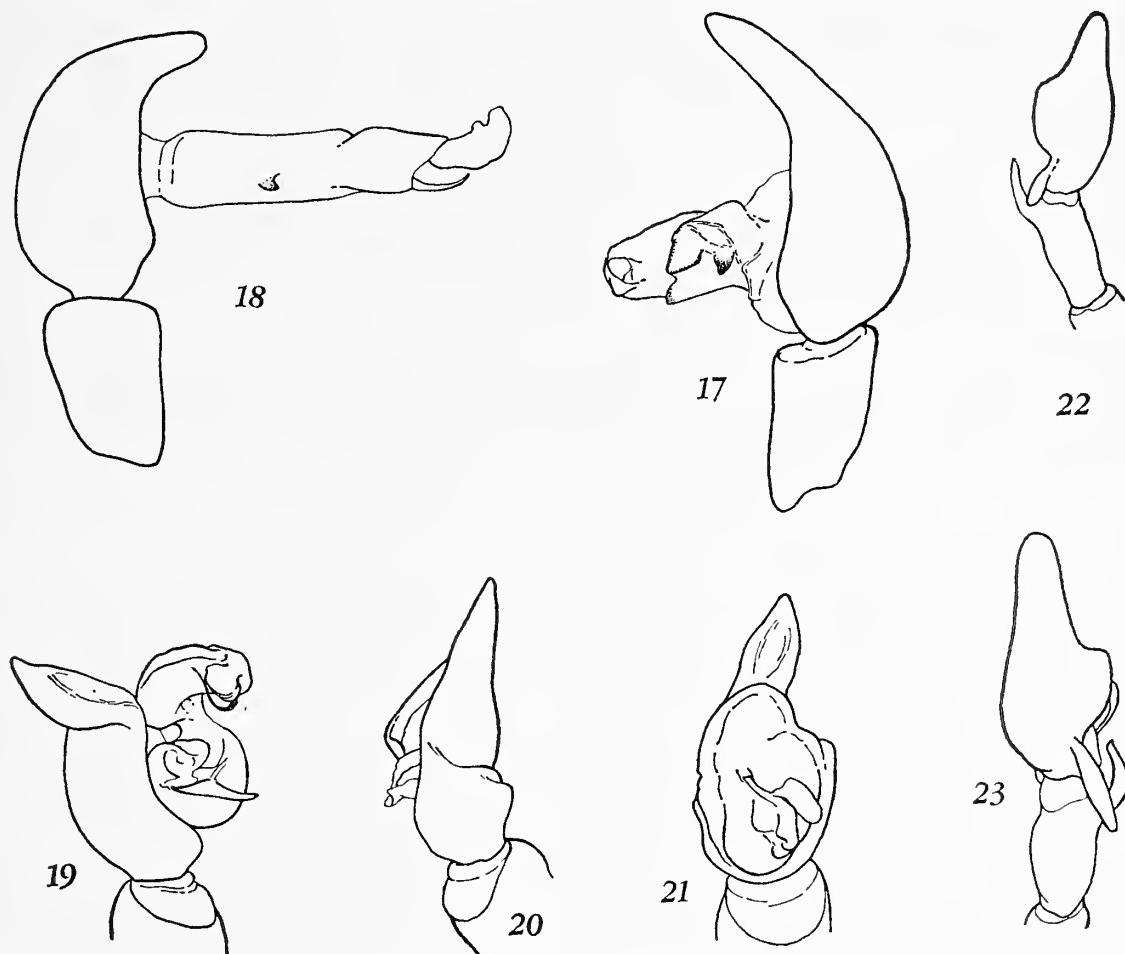
No. 14 *Chiracanthium inclusum* (Hentz)

The spider was collected at Grant's Blowing Spring, Georgia by M. H. Hatch on August 26, 1936. The left palp shows a cymbium of reduced size, about two-thirds that of the normal (compare figures 22 and 23). Also, the cymbial spur, which projects over the tibial apophysis, is considerably shorter than its normal mate. An examination of the palpal organs themselves shows that in the left (*i.e.* abnormal) palp the embolus terminates quite close to the distal tip of the cymbium, while in the normal palp the end of the embolus is quite some distance removed from the tip of the elongated cymbium.

DISCUSSION

Kolosvary (1943) published a note on what he considered abnormal epigyna in three specimens of *Salticus cingulatus* (Panzer) (sub *Epiblemmum*) taken in Hungary. But it seems quite likely that the "Wucherung" he noted in each specimen was merely the hardened colleterial fluid adhering from a previous oviposition (see Kaston 1948). As to anomalies exhibited in the females described here I am unable to offer any explanation for no. 1, *Pardosa fuscula*. In numbers 2 and 3 the one-sided development of the epigynum is similar to what is seen in bilateral gynandromorphs.

Concerning the anomalies displayed in the males, one must assume that for the most part these involve defective regeneration. Such defective palpi have been described by Chrysanthus (1955) for *Pachygnatha clercki* Sundevall, *Steatoda bipunctata* (Linnaeus), and *Meta segmentata* (Clerck) (sub *mengei*), and



17. *Pardosa californica*, ectal aspect of deformed left palp.
18. Same specimen, ectal aspect of deformed right palp.
19. *Lycosa ammophila*, ectal aspect of deformed right palp.
20. Same specimen, ectal aspect of deformed left palp.
21. Same specimen, ventral aspect of left palp.
22. *Chiracanthium inclusum*, dorsal aspect of deformed left palp.
23. Same specimen, normal right palp at same scale for comparison.

of course by Bonnet (1930) for *Dolomedes fimbriatus* (Clerck) in his detailed study on regeneration. Bonnet showed that if a male spider lost a palp, or part of a palp, no later than the pre-antepenultimate instar (*i.e.*, if it still had three ecdyses to undergo before becoming mature), the palp would be regenerated perfectly. Of course the length of time from injury to molting is important, for there must be an interval of at least three-

fourths as long as the interval between the molts themselves. If the loss takes place during the antepenultimate instar, with only two ecdyses left to undergo, the palp may be regenerated, but may not attain its full size. This is probably the explanation for my cases no. 4 and no. 14. Petrunkevitch (1930) recorded, but did not figure, what he assumed to be such a regenerated palp on the right side of a specimen of *Corinna abnormis* Petrunkevitch.

In some of Bonnet's cases deformed palps were produced. When the loss of the palp occurred during the penultimate instar, with only one more molt to be undergone, the palp did not regenerate properly, and a wide variety of bizarre and grotesque structures were produced. Some of these were figured by him on pages 630 and 634.

Of the eleven cases of palpal anomalies here described it would appear that numbers 5 and 6 suffered a loss of the palpal tarsus during the penultimate instar, so that the regenerated segment formed as a cymbium, but without an alveolus, somewhat as shown by Bonnet in his figures 121.7 and 121.10. Cases no. 7, 8, 9, and 10 probably arose in a similar manner, except that it here appears that not only the tarsus, but also the tibia was lost and subsequently regenerated. In these the tarsus did not develop sufficiently to show a cymbial form. In cases no. 9 and 10 it is possible to see the palpal organ developing within the tarsus much as in the case of a normal penultimate male. In case no. 11 it would appear that while the *right* palp suffered injury to tibia and tarsus in the penultimate instar, on the *left* side only the tarsus was involved. Case no. 12 is somewhat similar to those illustrated by Bonnet in his figures 121.16 and 121.18.

Case no. 13, alone among my specimens, appears to be due, not to an imperfect regeneration, but to some mechanical trauma to which the palps were subjected, perhaps at the time of molting itself.

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**ON THE MALE OF *TRIGONA (TETRAGONA)*
FIMBRIATA SMITH (HYMENOPTERA:
APIDAE)¹**

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ABSTRACT

Two male specimens of stingless bees collected in Thailand in January, 1958 together with six workers of *T. fimbriata* var. *aliceae* Cockerell, are described as the heretofore unknown male of *T. fimbriata*.

In examining the bee specimens collected by the Osaka City University Biological Expedition to Southeast Asia (1957-58), I found two male specimens of the stingless bee, which indubitably represent the still undescribed male of *Trigona (Tetragona) fimbriata* Smith as described below.

As already pointed out by Schwarz (1939, Bull. Amer. Mus. Nat. Hist., **76**, 83-141), this species takes a unique position in *Tetragona* (s. lat.) by lacking a sericeous area on the base of inner surface of worker hind basitarsi, which is present in all other Oriental *Tetragona*, while absent in most Neotropical relatives. Prior to this, the systematics of stingless bees has principally been based upon the worker caste. The comparative study of reproductive castes may help solve the systematic relation within *Tetragona* of both Old and New World tropics. However, for the lack of sufficient material, the comparison of the specimens examined with the males of related species was abandoned in the present work, and awaits accumulation of further material.

Recently, Moure (1961, Studia Entom., **4**, 181-242) erected a new genus, *Homotrigona*, for the reception of *T. (T.) fimbriata*. Clearly, this species occupies a remote position from other oriental

¹ Submitted for inclusion in the **Herbert F. Schwarz Memorial Volume** (1962) but delayed in publication due to lack of space, cf., 70 p. 214.

Trigona species. The conservative system of Schwarz is here followed inasmuch as I am not yet in a position to admit or deny the system of Moure. The two specimens examined were collected

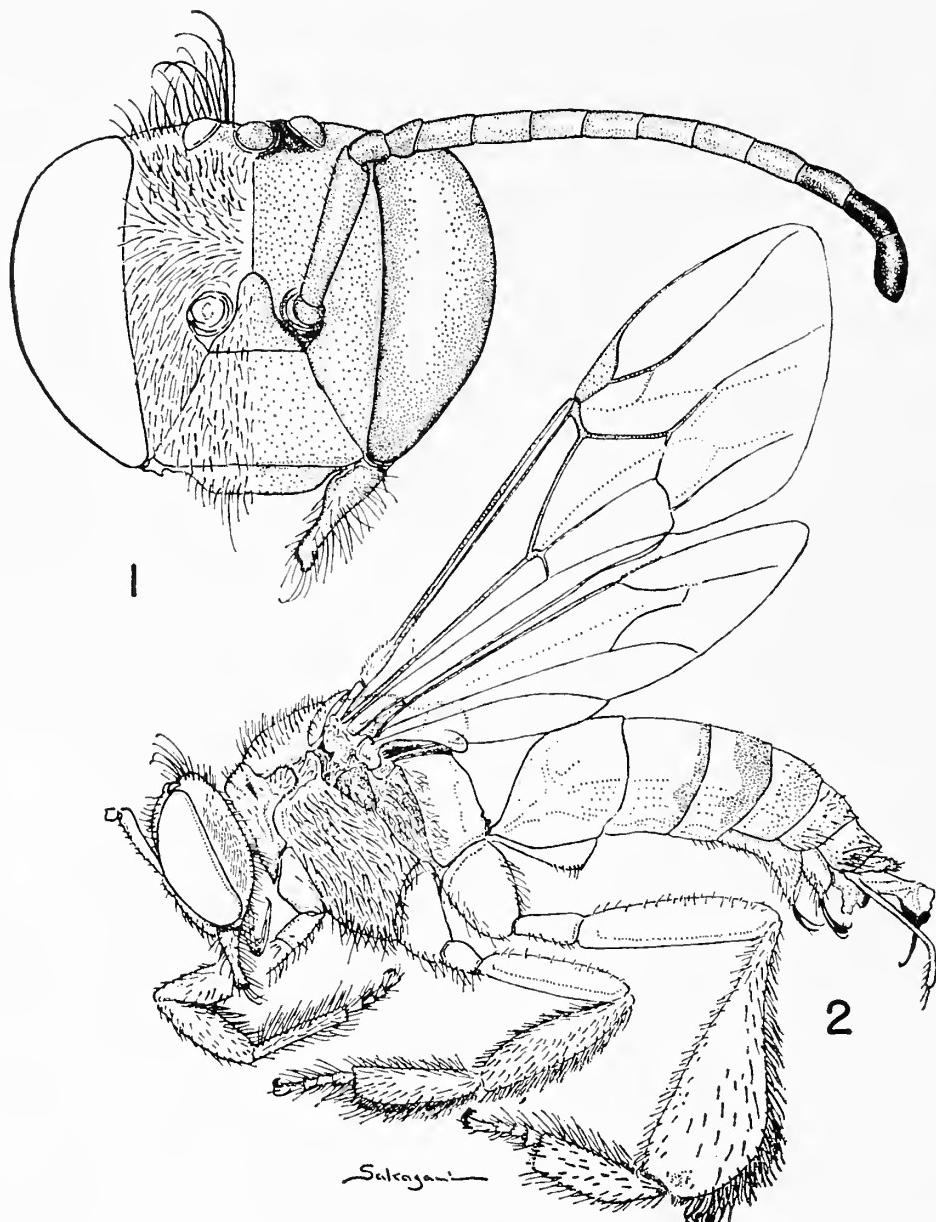


Fig. 1. Head, frontal view. Fig. 2. General appearance, lateral view.

together with six workers of *T. fimbriata* var. *aliceae* Cockerell and agree with *aliceae* by the possession of a narrow black transverse band on most of the metasomal terga.

Trigona fimbriata Smith

MALE General appearance as in worker, sexual dimorphism relatively little, especially in structure of hind-legs.

COLORATION Brown to reddish brown, with tint variable in various body parts as in worker. Mandibles externally, clypeus, laterally, lower paraocular areas along epistomal sutures, pronotum medially, mesoscutellum and mesoepisternum more or less paler. Apical club of volsellae pale brown.

Mesoscutal disc, metasomal terga partly, femora and tibiae of mid and hind legs, and antepenultimate flagellar segment more or less darker. Stematum, two apical flagellar segments, area surrounding foramen magnum, subantennal area (paler in one specimen), lateral pronotal spots, mesoscutum and scutellum marginally, submedian spots in anterior margin of mesoscutellum, hypoepimeral area of mesopleura, metaepisternum, margins of mid and hind tibiae, mid and hind basitarsi dorsally black to blackish brown. Sagittal projection black, abruptly contrasting. Metasomal terga with dark transverse stripes (= var. *aliceae* Cockerell), partly caused by strongly chitinized antecosta of succeeding terga inserted below. Wings pale brown, basal halves, veins and pterostigma brownish.

PILOSMY Stout, erect and black hairs dense and longer on vertex, slightly curled medially, distinctly longer than in worker; short and sparse on ocellular area and pronotum dorsally; sparse and short on supraclypeus and lateral lobes of pronotum; moderately dense and long on paraocular areas above, clypeus, mesoscutum and mesoscutellum, though longer than in worker, especially mesoscutellum marginally; dense, paler and slightly appressed on genae below and mesopleura, longer than in worker; stout and paler on mandibles posteriorly with apical hairs curled; stout on legs, spinous, dense and very long on tibiae and basitarsi except for dorsal surfaces where sparser; on metasomal terga lateroposteriorly short and erect on tergum IV, longer and stouter on V, rather spinous on VI; on basal metasomal sterna laterally dense and very short, gradually longer on apical sterna, changing to lateral fringes.

More delicate pale brown to golden hairs (intermingled or not with black hairs) long and appressed outwards on face laterally; minute and more or less appressed on supraclypeus, clypeus and genae immediately behind eyes; very fine and erect on scapes; dense, short and even on lateral lobes of pronotum, mesoscutum, mesoscutellum, meso and metapleura and propodeum laterally, much developed than in worker, forming undercoat. Appressed golden microtrichia on terga and sterna posteriorly dense and even, forming tonmental bands on terga II and III, wider on III, sparser on other terga. Shortest but rather stout microtrichia on posterior halves of ventral elevation of mid and hind tibiae very dense. Branched black hairs on posterior margins of mid tibiae about as long as maximum width of segment, longer than half width of segment on posterior margins of hind-tibiae. Hairs of anterior fringes of mid- and hind-basitarsi partly slightly branched. Propodeum medially and metasomal terga anteriorly without hairs, as on some minor areas of legs.

PUNCTATION In general smooth and more or less shining except for ventral elevation of mid and hind tibiae posteriorly and some limited parts of legs. Trichogenous punctures more or less darker, especially on clypeus, supraclypeus, lowest parts of paraocular areas and some parts of legs.

STRUCTURE Head distinctly wider than long (42:31), inner orbits slightly convergent. Ratio of interalveolar to alveorbital distance about 4:10 at same level (8.5:6.5 in worker). Ratio of eye to gena at widest part of head in profile 10:6. Ocelli nearly in a straight line, postocellar line slightly be-

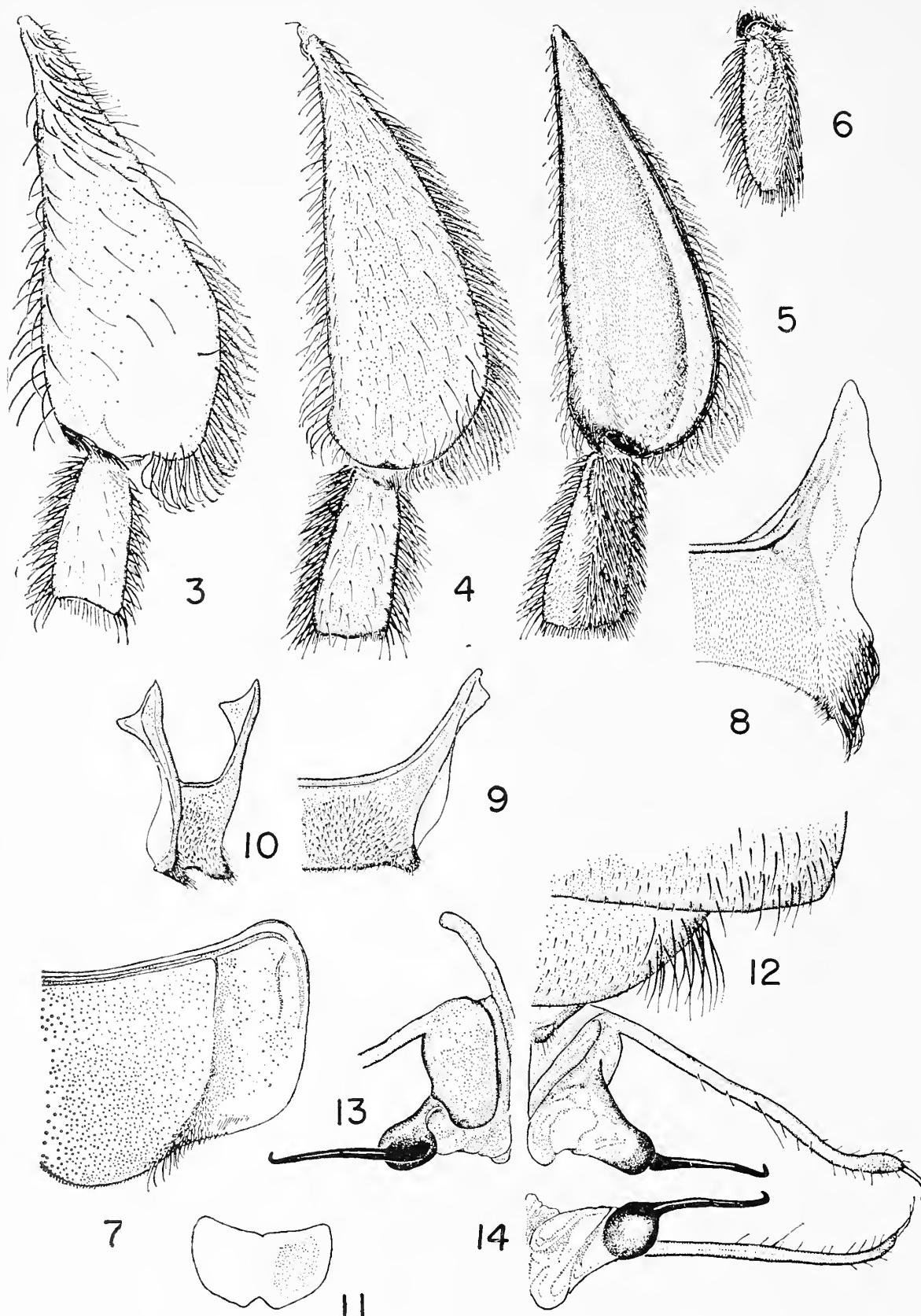


Fig. 3. Left hind tibia and basitarsus, dorsal view. Fig. 4. Ditto. Fig. 5. Right hind tibia and basitarsus, ventral view. Fig. 6. Right hind basitarsus, antero-ventral view. Figs. 7-9. Sternata IV-VI, ventral view. Fig. 10. Sternum VI, ventralateral view. Fig. 11. Sternum VII, ventral view. Figs. 12-14. Genitalia, dorsal, ventral and posterior (ventral side below) views. (Figs. 3, worker; all others, male).

hind postocular line, stematicum distinctly elevated, each ocellus situated as if slightly socketed, lateral ocelli oblique. Ratios in ocellocular area: diameter of median ocellus (4), of lateral ocelli (3.5), distance between median and lateral ocelli (1.5), distance between lateral ocelli (7), ocellocular distance (5). Supraclypeus slightly raised, lateral margins gently concave. Subantennal area depressed, rather conspicuous for dark coloration. Clypeus flat, upper and lower margins nearly straight, lateral margins seldom concave at tentorial pits; apicolaterally separated from eyes by space about one fifth of flagellar width. Labrum straight, laterally rounded. Mandibles distinctly overlapping one another, widest at base where about five times wider than at middle; with two inconspicuous apical dentitions, outer one slightly larger. Scape shorter than in worker (12:17), about as long as one fourth of pedicel and flagella combined. Seen frontally, pedicel and flagellum I about as long as wide, other flagella similar in size, about two times as long as wide, cylindrical; apical five segments with upper margin slightly convex; apical segment geniculate, swollen below, obliquely truncate apically.

Mesosoma about as wide as head. Pronotum not markedly sunken. Tegulae prominent. Mesoscutum and scutellum not markedly convex, both in same level, latter distinctly depressed anteriorly, projecting posteriorly without much exceeding propodeal declivity.

Wings distinctly exceeding metasoma. Pterostigma about 4.5 times as long as wide, gradually tapering apically. Marginal cell about 2.8 times as long as pterostigma, gradually tapering apically. Veins Rs rather straight. Vein Rs^2 obsolete in anterior half, disappearing posteriorly, veins 1 r-m and 2 r-m absent.

Legs similar to those of worker. Relative lengths of mid and hind tibiae and basitarsi not markedly different from those in worker: L/W of mid-tibiae 30/9 both in male and worker, of mid-basitarsi 26/8 in male while 24/8 in worker, of hind tibiae 50/18 in male and 52/20 in worker, of hind basitarsi 23/9 in both male and worker. Mid tibiae dorsally convex, ventrally rather flat with median longitudinal naked area. Mid basitarsi straight anteriorly while slightly convex posteriorly; postapical angle round; dorsal surface flat; ventral surface divided into anterior and posterior slope by means of weak longitudinal ridge; anterior slope with dense and short hairs, posterior slope with long and spinous bristles. Hind-tibiae dorsally slightly convex, with scattered, rather short spinous hairs; apical comb relatively well developed; ventral elevation similar to that of worker, anteriorly with sparse hairs, posteriorly with dense, shortest spinous microtrichia, boundary of both areas distinct but not demarcated by ridge (not sharply ridged in worker, too); marginal area broad posteriorly, with submarginal longitudinal depression. Hind-basitarsi dorsally flat; ventrally with conspicuous subbasal ridged tubercle, gradually tapering apically; anterior slope of tubercle steep, slightly concave and highly shining, posterior slope gradually tapering; differentiation of anterior and posterior areas more distinct at basal one thirds alone, pubescence sparse anteriorly, while denser posteriorly.

Metasoma about as wide as mesosoma, remarkably flat, relatively elongate and not triangular apically. Tergum VII flat basally, with semicircular

carina; steeply descending laterally, blunt and slightly tuberculate apically, Median incision of sternal margins inconspicuous in sternum I, gradually becoming acute in posterior sterna, resulting in two semicircular lateral lobes in sterna III and IV, together with development of lateral inflexion bearing spinous hairs. Sternum V with conspicuous antero-lateral processes with chitinous streak; median depression wide, anteriorly reaching nearly antecosta, with dense and even microtrichia; posterior margin semicircular, hairless and almost transparent medially; apicolateral processes prominent, apically obliquely truncale, with long and curled bristles. Sternum VI not extremely modified, antero-lateral processes long with triangular lateral lamella; median bulk relatively large, with dense, stout and short hairs, slightly sparse along median longitudinal line, hairs partly with apices sharply bending; posterior margin straight, with obscure submedian convexities, heavily chitinized; postlateral angle obliquely protruded; seen laterally, posterior margin, especially postlateral processes raised ventrally. Sternum VII small, poorly chitinized, semicircular, with distinct median incision in posterior margin. Volsellae obliquely issuing from anterior outer corner of quadrate stipes, distinctly longer than sagittal projection, slightly sinuous, with width same throughout, with scattered fine and erect hairs, apically gently bending and slightly swollen. Sagitta prominent, lateral tubercles blackish, projecting laterally; apical projections issuing laterally from ventral surface of tubercles, sharply differentiated from bulk of tubercle, jet black and very slender, slightly sinuous and gradually narrowing apically with hooked apex.

SPECIMENS EXAMINED Two males, KomPomCham, Thailand, Jan. 20, 1958, K. Yoshikawa. Deposited in the Entomological Laboratory, Hyogo Univ. Agric., Sasayama, Japan.

Acknowledgments

The writer wishes to express his thanks to Dr. Kunio Iwata and Dr. Kimio Yoshikawa for the loan of valuable specimens and to Prof. Pe. J. S. Moure, CMF, for his encouragement for the present work. When the specimens were examined, Mr. H. F. Schwarz was still alive and gave me kind suggestions. It is the pleasure as well as the sorrow of the writer that he presents this article to the commemoration volume of a grand expert of stingless bees. The examination of specimens was made in Japan. Even after the final completion of the manuscript in Brazil, the writer felt the description still insufficient in respect to relative head ratios, which will be added in another paper.

**AN ANNOTATED LIST OF THE LYCAENIDAE
(LEPIDOPTERA: RHOPALOCERA) OF THE
WESTERN HEMISPHERE**

BY WILLIAM PHILLIPS COMSTOCK AND EDGAR IRVING HUNTINGTON

[CONTINUED]

pseudofea Morrison, H. K., *Lycaena*

Type Locality: Key West, Florida.

Location of Type: Edward Burgess and H. K. Morrison Collections.

Original Description: 1873 (November), Bull. Buffalo Soc. Nat. Sci., vol. 1, p. 186 (Buffalo, N. Y.).

Additional Reference: Comstock, W. P. and E. I. Huntington, 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 111 (New York). (Consider *pseudofea* a good species.)

pseudolongula Clench, Harry K., *Thecla*

Type Locality: Mapoto, Ecuador.

Location of Type: Museum of Comparative Zoology, no. 26,223.

Original Description: 1944 (July), Bull. Mus. Comp. Zool., vol. 94, p. 235 (Cambridge, Mass.).

Note: Clench cites Hewitson's figs. 651-654 on pl. 80 in the Illus. of Diurnal Lepidoptera as his *pseudolongula*.

pseudoptiletes Boisduval, Jean A. and John LeConte, *Argus*

Type Locality: Carolina, Virginia and Georgia.

Location of Type:

Original Description: 1833, Histoire Générale et iconographie des Lépidoptères et des chenilles de l'Amérique Septentrionale, p. 114, pl. 35, figs. 5-7 (Paris).

Additional References: Scudder, Samuel H., 1876 (May), Bull. Buffalo Soc. Nat. Sci., vol. 3, p. 123 (Buffalo, N. Y.). (Places *pseudoptiletes* as a synonym of *antibubastus* Hübner.) Comstock, W. P. and E. I. Huntington, 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 109 (New York). (Make *pseudoptiletes* a synonym of *antibubastus* Hübner.)

pseudora Scudder, Samuel H., *Cyaniris pseudargiolus* ab.

Type Locality: Milford, New Hampshire, May 23 (♀).

Location of Type:

Original Description: 1889, The Butterflies of the eastern United States and Canada with special reference to New England, vol. 2, p. 933 (Cambridge, Mass.).

pseudosamuelis Nabokov, V., *Lycaeides melissa*

Type Locality: vicinity of Red Mt. Inn, Highway 82, between Mt. Elbert and La Plata, Pitkin County, Colorado.

Location of Type: Museum of Comparative Zoology, Cambridge, Massachusetts.

Original Description: 1949 (February), Bull. Mus. Comp. Zool., vol. 101, no. 4, p. 529, pl. 1, fig. 28, pl. 6, fig. 75, pl. 9, fig. 120 (Cambridge, Mass.).

psyche Boisduval, Jean A. and John LeConte, *Thecla*

Type Locality: Georgia.

Location of Type:

Original Deserction: 1833, Histoire Générale et iconographie des Lépidoptères et des chenilles de l'Amérique Septentrionale, p. 88, pl. 27 (Paris).

Note: Boisduvel considered this a variety of *m-album* and it is now generally regarded as a synonym.

publica Robert J., *Thecla*

Type Locality: Río Magdalena, Western Colombia (1 ♀).

Location of Type:

Original Description: 1923, Ent. Mitt., vol. 12, p. 58 (Berlin).

Note: Near *paphia* Felder.

pudica Edwards, Henry, *Thecla melinus* var.

Type Locality: Contra Costa County, California, June, 1875.

Location of Type: American Museum of Natural History (1 ♀).

Original Deserption: (1876), 1877, Proc. Calif. Acad. Sci., vol. 7, p. 172 (San Francisco, Calif.).

pulchritudo Druce, Hamilton H., *Thecla*

Type Locality: Amazons.

Location of Type: Druce Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 597, pl. 35, fig. 11 ♂ (London).

punctum Herrich-Schäffer, G. A. W., *Thecla*

Type Locality: Surniam.

Location of Type:

Original Description: 1858 (April), Sammlung aussereuropäischer Schmetterlinge, p. 55, figs. 57, 58 (Regensburg).

Additional References: Hewitson, W. C., 1869 (April), Illus. of Diurnal Lepidoptera, vol. 1, p. 109, vol. 2, pl. 40, figs. 132, 133 ♂ (London); 1874 (December), *op. cit.*, vol. 1, p. 183, vol. 2, pl. 72, figs. 555, 556 ♂ (London).

punona Clench, Harry K., *Thecla*

Type Locality: Puno, Peru, 1200 ft., November 1, 1898.

Location of Type: Museum of Comparative Zoology, no. 26,258.

Original Description: 1944 (September), Jour. New York Ent. Soc., vol. 52, p. 256 (New York).

pupilla, Draudt, Max, *Thecla*

Type Locality: Guiana to Colombia and Bolivia.

Location of Type:

Original Description: 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 801, pl. 158-i (Stuttgart).

puppius Godman, F. D. and O. Salvin, *Thecla*

Type Locality: British Guiana.

Location of Type: British Museum (Natural History).

Original Description: 1887 (September), Biologia Centrali-Americana Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 84 (London).

pura Draudt, Max, *Thecla*

Type Locality: Sao Paulo, Brazil (1 ♂).

Location of Type:

Original Description: 1919 (December), The Macrolepidoptera of the World, vol. 5, p. 764, pl. 154-c (underside) (Stuttgart).

purissima Draudt, Max, *Thecla*

Type Locality: Lino, Panamá.

Location of Type: Fassl Collection (1 ♀) (now in Naturhistorisches Museum, Basle).

Original Description: 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 788, pl. 156-k (Stuttgart).

purpura Druce, Hamilton H., *Thecla*

Type Locality: Espiritu Santo, Brazil.

Location of Type: Druce Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 592, pl. 34, fig. 20 ♂ (London).

purpurantes Druce, Hamilton H., *Thecla*

Type Locality: Peru.

Location of Type: Druce Collection

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 597, pl. 35, fig. 7 ♂ (London).

Additional reference: Druce, H. H., 1909 (September), Trans. Ent. Soc. London, p. 435, pl. 11, fig. 12 ♀ (London). (Gives locality San Remon, Peru, 3000 ft., in J. H. Adams Collection, taken in August.)

purpuriticus Druce, Hamilton H., *Thecla*

Type Locality: Interior of Colombia.

Location of Type: Druce Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 601, pl. 36, fig. 2 ♂ (London).

putnami Scudder, Samuel H., *Thecla Nomen nudum* See *Thecla putnami* Henry Edwards

Type Locality:

Location of Type:

Original Description: 1876 (May), Bull. Buffalo Soc. Nat. Sci., vol. 3, p. 109 (Buffalo, N. Y.).

putnami Edwards, Henry, *Thecla*

Type Locality: Mt. Nebo, Utah, July, 1875 (1 ♀).

Location of Type: American Museum of Natural History.

Original Description: 1877, Proc. Calif. Acad. Sci., vol. 7, p. 143 (San Francisco, Calif.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 24, no. 384 (Los Angeles, Calif.). (Places *putnami* as a subspecies of *sylvinus* Boisduval.)

pyrrhias Godman, F. D. and O. Salvin, *Chrysophanus?*

Type Locality: Chilasco, Guatemala.

Location of Type: British Museum (Natural History).

Original Description: 1887 (October), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 101, vol. 3, pl. 58, figs. 26, 27 ♂ (London).

quaderna Hewitson, W. C., *Thecla*

Type Locality: Mexico.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 35 (London).

Additional Reference: Hewitson, W. C., 1878 (November), Illus. of Diurnal Lepidoptera, vol. 1, p. 209, vol. 2, pl. 83, figs. 703, 704 (London).

Subspecies: *sanfordi* dos Passos.

quadrимaculata Hewitson, W. C., *Thecla*

Type Locality: Chile.

Location of Type: British Museum (Natural History).

Original Description: 1874, Ent. Mo. Mag., vol. 11, p. 106 (London).

Additional References: Hewitson, W. C., 1877 (January), Illus. of Diurnal Lepidoptera, vol. 1, p. 208 (London). (Makes *quadrимaculata* a synonym of *bicolor* Philippi.) Butler, A. G., 1881, Trans. Ent. Soc. London, p. 468 (London). (Places *quadrимaculata* male as female of *bicolor* Philippi and rerecognizes *quadrимaculata* female for which he apparently had males, as a separate species.)

quadrufus Hayward, Kenneth J., *Thecla loxurina* form

Type Locality: Sierras de Clavillo (Tecumán) 2000 m., November, 1933.

Location of Type: Collection Alberto Breyer.

Original Description: 1935, Rev. Soc. Ent. Argentine, vol. 7, p. 191 (Buenos Aires).

quassa Draudt, Max, *Thecla*

Type Locality: Santa Catharina, Brazil (1 ♂).

Location of Type:

Original Description: 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 784, pl. 156-a (Stuttgart).

quesnelli Cockle, J. W., *Cyaniris ladon* var.

Type Locality: Bala Lake, Quesnelle, Northern British Columbia.

Location of Type:

Original Description: 1910 (June), Can. Ent., vol. 42, p. 204 (London, Ont.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 29, no. 475 (Los Angeles, Calif.). (Places *quesnelli* as a form of *pseudargiolus nigrescens* Fletcher.)

Synonyms: *maculata-suffusa* Cockle.

quindiensis Draudt, Max, *Thecla luxurina* form

Type Locality: Quindiu Pass, Colombia, 3800 meters.

Location of Type:

Original Description: 1919 (December), The Macrolepidoptera of the World, vol. 5, p. 758, pl. 153-e (Stuttgart).

radialis Druce, Hamilton H., *Theela*

Type Locality: Pará, Brazil.

Location of Type: Godman Collection, British Museum (Natural History).

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 586, pl. 34, fig. 8 ♂ (London).

ramon Dognin, P., *Lycaena*

Type Locality: Loja, Ecuador.

Location of Type:

Original Description: 1887 (November), Le Naturaliste, 2nd Series, no. 16, p. 189, fig. 4 (Paris).

Additional References: Dognin, P., 1887, Note sur la Faune des Lépidoptères de Loja, p. 23, pl. 2, fig. 5 (Paris). Ureta R., Emilio, 1949, Boletín del Museo Nacional de Historia Natural, vol. 24, p. 108 (Santiago, Chile). (Makes *ramon* a subspecies of *ceraunus* Fabricius).

rana Schaus, William, *Thecla*

Type Locality: Castro, Paraná, Brazil.

Location of Type: United States National Museum, no. 5939.

Original Description: 1902, Proc. U. S. Natl. Mus., vol. 24, p. 414 (Washington, D. C.).

Additional Reference: Druce, H. H., 1907, Proc. Zool. Soc. London, p. 628 (London). (Makes *rana* a synonym of *erytulus* Hübner.)

rapahoe Reakirt, Tryon, *Lycaena*

Type Locality: Rocky Mountains, Colorado.

Location of Type: Strecker Collection (1 ♂, 1 ♀), Field Museum, Chicago, Illinois.

Original Description: 1866 (June), Proc. Ent. Soc. Phila., vol. 6, p. 146 (Philadelphia, Pa.).

Additional Reference: Barnes, William and J. H. McDunnough, 1917 (February), Check list of the Lepidoptera of boreal America, p. 16, no. 433

(Decatur, Ill.). (Place *rapahoe* as a synonym of *icariooides lycea* Edwards.)

ravus Druce, Hamilton H., *Thecla*

Type Locality: Amazons, Brazil.

Location of Type: British Museum (Natural History).

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 582, pl. 33, fig. 12 ♂ (London).

reakirti Field, William D., *Leptotes marina* ♀ f.

Type Locality: Mesa Butte, Arizona, August 10, 1930.

Location of Type: W. D. Field Collection, Lawrence, Kansas. (United States National Museum?).

Original Description: 1936, Jour. Ent. Zool., vol. 28, p. 26, Pomona College (Claremont, Calif.).

reducta Lathy, Percy I., *Thecla cyllarus*

Type Locality: Rio Tono, Peru, 1200 ft. (La Merced, Peru, 3000-4500 ft.)

Location of Type: Fournier Collection, Paris.

Original Description: 1926, Ann. Mag. Nat. Hist., Series 9, vol. 17, p. 44 (London).

regalis Cramer, Pierre, *Papilio*

Type Locality: Surinam.

Location of Type:

Original Description: 1775, Papillons exotiques des trois parties du monde, vol. 1, p. 114, pl. 72, figs. E, F (Amsterdam).

Synonyms: *endymion* Fabricius.

regia Boisduval, Jean A., *Lycaena*

Type Locality: Los Angeles, California.

Location of Type: United States National Museum.

Original Description: 1869, Ann. Soc. Ent. Belgique, vol. 12, p. 46 (Bruxelles).

Additional References: Strecker, Herman, 1878, Butterflies and Moths of North America. A Complete Synonymical Catalogue, p. 96 (Reading, Pa.). (Places *regia* as a synonym of *sonorensis* Felder and Felder.) Oberthür, Charles, 1913 (October), Etudes de lepidoptorologie Comparee, fasc. 9, pt. 1, p. 42, pl. 238, figs. 1957 ♂, 1958 ♀ (Rennes).

remus Hewiston, W. C., *Thecla*

Type Locality: Brazil.

Location of Type: Boisduval Collection. (British Museum?)

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 34 (London).

Additional Reference: Hewitson, W. C., 1877 (January), Illus. of Diurnal

Lepidoptera, vol. 1, p. 201, vol. 2, pl. 80, figs. 655, 656 ♂ (London).

Synonyms: *deidamia* Burmeister.

renarius Butler, A. G., *Tmolus*

Type Locality:

Location of Type:

Original Description: 1873 (October), Lepid. Exot., p. 162 (London).

Additional Reference: Hewitson, W. C., 1877 (January), Illus. of Diurnal Lepidoptera, vol. 1, p. 193 (London). The name *renarius* is a misspelling of *denarius* and a synonym.)

renidens Draudt, Max, *Thecla*

Type Locality: Marcapata, Peru; Bolivia.

Location of Type:

Original Description: 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 793, pl. 157-h (Stuttgart).

restricta Lathy, Percy I., *Thecla*

Type Locality: Salta, Northern Argentine.

Location of Type: Fournier Collection, Paris.

Original Description: 1936, Livre jubilaire de M. Eugene-Louis Bouvier, p. 230, pl. 8, fig. 9 (Paris).

rhea Boisduval, Jean A., *Lycaena*

Type Locality: Los Angeles, California.

Location of Type: United States National Museum?

Original Description: 1869, Ann. Soc. Ent. Belgique, vol. 12, p. 51 (Bruxelles).

Additional References: Oberthür, Charles. 1913 (October), Etudes de Lépidoptérologie Comparee, fasc. 9, pt. 1, p. 43, pl. 239, figs. 2078 ♂ 2079 ♀ (Rennes). McDunnough, J. H., 1938, Check list, pt. 1, p. 28, no. 472 (Los Angeles, Calif.). (Places *rhea* as a synonym of *piasus catalina* Reakirt.)

rhodope Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Northern Sonora, Mexico.

Location of Type: British Museum (Natural History).

Original Description: 1887 (June), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 48, vol. 3, pl. 54, figs. 3, 4 ♂ (London).

ricei Cross, Frank Clay, *Plebeius scudderii*

Type Locality: Big Cultus Lake, Oregon, August, 1936.

Location of Type: Cross Collection, Colorado Museum of Natural History.

Original Description: 1937 (January and April), Pan-Pacific Ent., vol. 13, nos. 1 and 2, p. 88 (San Francisco, Calif.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 27, no. 451 (Los Angeles, Calif.). (Places *ricei* as a synonym of *anna* Edwards.)

rickmani Schaus, William, *Thecla*

Type Locality: Colombia.

Location of Type: United States National Museum, no. 5931.

Original Description: 1902, Proc. U. S. Natl. Mus., vol. 24, p. 411 (Washington, D. C.).

rinde Dyar, Harrison, G., *Thecla arindela*

Type Locality: Sierra de Guerreo, Mexico, December, 1910.

Location of Type: United States National Museum, no. 19, 251.

Original Description: 1917, Proc. U. S. Natl. Mus., vol. 51, p. 2 (Washington, D. C.).

rita Barnes, William and J. H. McDunnough, *Lycaena*

Type Locality: Southern Arizona.

Location of Type: United States National Museum (Barnes Collection).

Original Description: 1916 (July), Can. Ent., vol. 48, p. 223 (London, Ont.).

rita Goodson, F. W., *Thecla*

Type Locality: Santa Rita, Cauca River, Colombia (3 ♂, 1 ♀).

Location of Type: British Museum (Natural History).

Original Description: 1945 (December), Entomologist, vol. 78, p. 187 (London).

rocena Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1 p. 91, vol. 2, pl. 37, figs. 96, 97 ♂ (London).

Subspecies: *major* Lathy.

romulus Fabricius, Johann Christian, *Hesperia*

Type Locality: "In Indiis".

Location of Type: Lost (H. H. Druce).

Original Description: 1793, Entomologica Systematica, vol. 3, p. 316 (Hafniae).

Additional References: Donovan, Edward, 1800, Ins. India, p. 51, pl. 46, fig. 5 (London). Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 568 (London).

Note: See Jones' *Icones* for possible determination.

ruberrothei Weeks, A. G., Jr., *Lycaena*

Type Locality: Sicasica, Boliva, October 1, 1899.

Location of Type: Museum of Comparative Zoology.

Original Description: 1902 (April), Ent. News, vol. 13, p. 104 (Philadelphia, Pa.).

Additional Reference: Weeks, A. G., Jr., 1905, Illus. of Diurnal Lepidoptera, p. 99, pl. 43, fig. 2 (Boston, Mass.).

rubidus Behr, Herman, *Chrysophanus*

Type Locality: Interior of Oregon (1 ♂).

Location of Type:

Original Description: 1866 (October), Proc. Ent. Soc. Phila., vol. 6, p. 208 (Philadelphia, Pa.).

Subspecies: *sirius* Edwards

rubifer Druce, Hamilton H., *Thecla*

Type Locality: Bogotá, Colombia.

Location of Type: British Museum (Natural History).

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 621 (London).

Additional Reference: Draudt, Max, 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 804 (Stuttgart). (Makes *rubifer* a synonym of *picentia* Hewitson.)

rufanalis Hayward, Kenneth J., *Thecla loxurina* f.

Type Locality: Sierras de Clavillo (Tucumán) 2000 m., November, 1933.

Location of Type: A. Breyer Collection.

Original Description: 1935, Rev. Soc. Ent. Argentine, vol. 7, p. 191 (Buenos Aires).

rufescens Boisduval, Jean A., *Lycaena*

Type Locality: Interior of California, May.

Location of Type: United States National Museum?

Original Description: 1869, Ann. Soc. Ent. Belgique, vol. 12, p. 48 (Bruxelles).

Additional Reference: Oberthür, Charles, 1913 (October), Etudes de Lepidopterologie Comparee, fasc. 9, pt. 1, p. 42, pl. 239, figs. 2067 ♂, 2068 ♀ (Rennes).

Note: This is the brown female form of *saepiolus* Boisduval.

rufo-fusca Hewitson, W. C., *Thecla*

Type Locality:

Location of Type: British Museum (Natural History).

Original Description: 1877 (January), Illus. of Diurnal Lepidoptera, vol. 1, p. 196, vol. 2, pl. 78, figs. 627, 628 ♀ (London).

Additional References: Godman, F. D. and O. Salvin, 1887 (September), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 91 (London). (Give the following localities: San Gerónimo and Choctum, Guatemala; Pernambuco, Brazil.) Comstock, W. P. and E. I. Huntington, 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 76 (New York).

Synonyms: *lucaris* Weeks.

rugatus Druce, Hamilton H., *Thecla*

Type Locality: Vina, NW Peru, 5500 ft.

Location of Type: Godman Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 611 (London).

Additional Reference: Draudt, Max, 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 797, pl. 158-d (Stuttgart).

rustan Stoll, Caspar, *Papilio*

Type Locality: "China".

Location of Type:

Original Description: 1790, Papillions exotiques des trois parties du monde, Supplement, p. 166, pl. 38, figs. 1, 1A (Amsterdam).

Additional Reference: Kirby, W. F. 1871, A Synonymic Catalogue of Diurnal Lepidoptera, p. 388 (London). (Gives locality as "Amer. mer.")

Synonyms: *macaria* Swainson.

rustica Edwards, William H., *Lycaena*

Type Locality: Pike's Peak, Colorado.

Location of Type:

Original Description: 1865, Proc. Ent. Soc. Phila., vol. 4, p. 203 (Philadelphia, Pa.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 27, no. 452 (Los Angeles, Calif.). (Places *rustica* as a subspecies of *aquilo* Boisduval.)

sabinus Felder, Cajetan and Rudolf Felder, *Thecla*

Type Locality: New Granada, Bogotá.

Location of Type:

Original Description: 1864-1867, Reise der Österreichischen Fregatte "Novara" um die Erde, vol. 2, p. 263, pl. 32, fig. 24 (Wien).

Additional Reference: Draudt, Max, 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 806 (Stuttgart). (Places *sabinus* as a southern form of *melinus* (Hübner)).

Synonyms: *promissa* Möschler.

sadiei Weeks, A. G., Jr., *Thecla*

Type Locality: Coroico, Bolivia, April 20, 1899.

Location of Type: Museum of Comparative Zoology.

Original Description: 1901 (December), Proc. N. E. Zool. Club, vol. 2, p. 101 (Cambridge, Mass.).

Additional Reference: Weeks, A. G., Jr., 1905, Illus. of Diurnal Lepidoptera, p. 100, pl. 44, fig. 1 (Boston, Mass.).

saepiolus Boisduval, Jean A., *Lycaena*

Type Locality: Mountains of California, June.

Location of Type: United States National Museum?

Original Description: 1852, Ann. Soc. Ent. France, Series 2, vol. 10, p. 296 (Paris).

Additional Reference: Oberthür, Charles, 1913 (October), Etudes de Lepi-

dopterologie Comparee, fasc. 9, pt. 1, p. 41, pl. 237, fig. 1941 ♂, 1942 ♀ (Rennes).

Synonyms: *boharti* Gunder, *leussleri* Gunder, *rufescens* Boisduval.

Subspecies: *aehaja* Behr, *amica* Edwards, *gertschi* dos Passos, *hilda* Grinnell, *garthi* Gunder syn., *insulanus* Blackmore.

saepium Boisduval, Jean A., *Thecla*

Type Locality: California.

Location of Type: United States National Museum?

Original Description: 1852, Ann. Soc. Ent. France, Series 2, vol. 10, p. 288 (Paris).

Additional Reference: Oberthür, Charles, 1913 (October), Etudes de Lepidopterologie Comparee, fasc. 9, pt. 1, p. 40, pl. 235, fig. 1922 (Rennes).

Synonyms: *sepium* (Zool. Record).

Subspecies: *chlorophora* Watson and Comstock, *fulvescens* Edwards, *okanagana* McDunnough, *provo* Watson and Comstock.

sagittigera Felder, Cajetan and Rudolf, Felder, *Lycaena*

Type Locality: Sonora, Mexico.

Location of Type:

Original Description: 1864–1867, Reise der Österreichischen Fregatte "Novara" um die Erde, vol. 2, p. 281, pl. 35, figs. 20, 21 ♂ (Wien).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 28, no. 472 (Los Angeles, Calif.). (Places *sagittigera* as a synonym of *piasus* Boisduval.)

sala Hewitson, W. C., *Thecla*

Type Locality: New Granada.

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 81, vol. 2, pl. 35, figs. 71, 72 ♀ (London).

salaeides Draudt, Max, *Thecla*

Type Locality: Pacho, Colombia.

Location of Type: Fassl Collection?

Original Description: 1919 (December), The Macrolepidoptera of the World, vol. 5, p. 754, pl. 159-a (underside) (Stuttgart).

salona Hewitson, W. C., *Thecla*

Type Locality: Venezuela.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 31 (London).

Additional References: Hewitson, W. C., 1874 (December), Illus. of Diurnal Lepidoptera, vol. 1, p. 159, vol. 2, pl. 63, figs. 429, 430 ♂ (London). Amazon. Druce, H. H. 1907 (June), Proc. Zool. Soc. London, p. 627 (London). (Makes *salona* a synonym of *bubastus* Cramer.). Draudt, Max, 1920, The Macrolepidoptera of the World, vol. 5, p. 809 (Stuttgart). (Makes *salona* a synonym of *bubastus* Cramer.)

samuelis Nabokov, V., *Lycaenides melissa* subsp.

Type Locality: Allotype female, Albany, New York.

Location of Type: Museum of Comparative Zoology.

Original Description: 1943, Psyche, vol. 50, nos. 3, 4, p. 97 (Cambridge, Mass.).

sanctissima Jorgensen, Pedro, *Thecla*

Type Locality: Santísima Trinidad near Asunción, Paraguay, November.

Location of Type: Museo Argentino de Ciencias Naturales, Buenos Aires.

Original Description: 1935, An. Mus. Argentino Cien. Nat., vol. 38, p. 93, pl. 2, fig. 6.

sanfordi dos Passos, Cyril F., *Erora laeta*

Type Locality: White Mountains, Arizona, 8000 ft., June 21, 1936.

Location of Type: American Museum of Natural History.

Original Description: 1940 (March), Amer. Mus. Novitates, no. 1052, p. 1 (New York, N. Y.).

Additional Reference: Clench, Harry K., 1943 (September), Jour. New York Ent. Soc., vol. 51, p. 223 (Lancaster, Pa.). As *Erora quaderna sanfordi*.

sangala Hewitson, W. C., *Thecla*

Type Locality: Venezuela.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 35 (London).

Additional Reference: Hewitson, W. C., 1869 (April), Illus. of Diurnal Lepidoptera, vol. 1, p. 132, vol. 2, pl. 54, figs. 314, 315 ♀ (London).

Synonyms: *autoclea* Hewitson, *callides* Dyar.

sanguinalis Burmeister, H., *Thecla*

Type Locality: Cordova and d'Enterrios, Argentina.

Location of Type:

Original Description: 1878, Desc. Physique République Argentine, vol. 5, Lepidoptera, pt. 1, 239, Atlas pl. 8, fig. 12 (Buenos Aires).

santans Dyar, Harrison G., *Thecla*

Type Locality: Acapulco, Mexico, September, 1925.

Location of Type: United States National Museum, no. 39,985.

Original Description: 1926, Insecutor Inscitiae Menstruus, vol. 14, p. 140 (Washington, D. C.).

sapho Staudinger, Otto, *Micandra*

Type Locality: Río San Juan, Panamá.

Location of Type: Staudinger Collection.

Original Description: 1888, Exotische Tagfalter, vol. 1, p. 289, vol. 2, pl. 97 ♂ (Bayern).

sapota Hewitson, W. C., *Thecla*

Type Locality: Payta.

Location of Type: British Museum (Natural History).

Original Description: 1877 (January), Illus. of Diurnal Lepidoptera, vol. 1, p. 203, vol. 2, pl. 81, figs. 668, 669 ♂ (London).

sarita Skinner, Henry, *Thecla*

Type Locality: Comal County, Texas.

Location of Type: Academy of Natural Sciences, Philadelphia, Pennsylvania.

Original Description: 1895, Ent. News, vol. 6, p. 112 (Philadelphia, Pa.).

Additional References: Skinner, Henry, 1898, Synonymic Catalogue of North American Rhopalocera, p. 48 (Philadelphia, Pa.). (Makes *sarita* a synonym of *simaethis* Drury.) Stallings, D. D. and J. R. Turner, 1947, Ent. News, vol. 58, p. 40 (Philadelphia, Pa.). (Make *sarita* a sub-species of *simaethis* Drury.)

satyroides Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1865, Illus. of Diurnal Lepidoptera, vol. 1, p. 74, vol. 2, pl. 29, figs. 10, 12 ♂, 13 ♀ (London).

scamander Hübner, Jacob, *Atlides*

Type Locality:

Location of Type:

Original Description: 1819, Verzeichniss bekannter Schmettlinge, p. 80 (Augsburg). (Proposes *scamander* as a new name for *atys* Cramer (Pap. Exot., vol. 3, pl. 259, figs. G, H). *Scamander* is a synonym of *atys*.

schausa Jones, E. Dukinfield, *Thecla*

Type Locality: Castro, Paraná; São Paulo, S. E. Brazil.

Location of Type: Jones Collection.

Original Description: 1912, Proc. Zool. Soc. London, p. 898, pl. 97, fig. 5 (London).

Note: This is a homonym of *Thecla schausi* Godman and Salvin, 1887.

schausi Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Jalapa, Mexico.

Location of Type: British Museum (Natural History).

Original Description: 1887 (October), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 98, vol. 3, pl. 58, figs. 22, 23 ♂ (London).

schellbachi Tilden, J. W., *Lycaena (Tharsalea) arota*

Type Locality: Bright Angel Trail, Grand Canyon, Arizona, June 11, 1943, June 22, 1943.

Location of Type: United States National Museum.

Original Description: 1955 (October), Bull. Southern Calif. Acad. Sci., vol. 54, pt. 2, p. 72, pl. 24, fig. 4 (Los Angeles, Calif.).

Necrology

It is with deep regret that we note the passing of three Honorary Members of the New York Entomology Department.

Axel Leonard Melander Died August 14, 1962

Associated with the Biology Department of the College of the City of New York, he was devoted to Biology in general and Entomology in particular. Under his guidance the department expanded and new appointments to his staff were made to biologists who were also well-trained in entomology. His book **The Classification of Insects**, written with Charles T. Brues, is still a classic. He published many monographs and articles on Diptera and his outstanding insect cinematography highlighted many of our Society meetings. All who knew him will remember him as a friend and scholar in whom the highest standards in teaching and research were combined with a warm, sensitive and sympathetic nature.

Robert Evans Snodgrass Died September 14, 1962

Coupled with his skill and insight as a professional artist which enabled him to illustrate his work with precise and elegant penwork, he brought to this subject an amazing capacity for accurate research, logical thinking and deep scholarship which made him the foremost morphologist of our time. Among his more than 80 publications are four full-sized books, of which **Principles of Insect Morphology** is still the definitive work.

Dr. Snodgrass was a modest, gracious, unassuming man possessed of a rich sense of humor which even appeared in his scientific writing. We who were privileged to know him personally will never forget him.

Edgar Irving Huntington Died November 21, 1962

Edgar I. Huntington joined the N. Y. Entomological Society when still in knee pants and for over 60 years has been one of its stalwart supporters. Real estate was his vocation, Entomology his hobby and the Lycaenidae of the New World his special interest. In 1944 he was appointed a Research Associate in the Museum's Entomology Department. Here he worked closely with the late W. P. Comstock—collaborating in **An Annotated List of Lycaenidae of the Western World** which is currently appearing in the JOURNAL.

For the past several years he served as a Trustee and as a member of the Publication Committee. His cheerful presence and good counsel will be missed.

PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF MARCH 1, 1960

The President called the meeting to order at 8:05 P.M. in Room 129 of the American Museum of Natural History; 24 members and 38 guests were present. The minutes of the previous meeting were accepted as read. Mr. Manlio A. Manzelli of Scotch Plains, N. J. was elected a member. The members were informed of the death of Dr. Harold R. Hagan, a past-officer and past-president. He was well-known to many of the present members. A letter from Mr. Harry Weiss, an Honorary Member and Editor Emeritus, told of the death of Mr. Harry G. Barber in Washington, D. C. He had been Secretary and Vice-president and then President in 1916 and 1917. Letters of sympathy are to be sent to the families of the deceased members. The following were proposed for membership: Mr. Donald Whitehead, Mr. Daniel Schweitzer, Mr. Gustav Garay, Mr. Thomas Bast, and Mr. M. Imberman. It was announced that Miss Dorothy Von Glahn has succeeded Ted Weinreich as President of the Junior Society. Mr. Robert Bloch spoke at their last meeting.

Dr. Roman Vishniac, a past-president and the speaker of the evening, was introduced by Mr. Shoumatoff. His talk entitled, "Color in Living Animals" was prefaced with remarks about his arrival in this country and his attendance at our meetings. He claimed to have learned English at these meetings, therefore, any accent he might have is an entomological one. He told of his strong feelings about studying only living organisms under natural conditions. He discussed his philosophy of nature and living things, the evolution and the study of life from its earliest stages to its most advanced forms. He referred to the advancement of biological knowledge in the past 50 years and had some thoughts on future progress. A color film in the usual Vishniac tradition was shown. The startling pictures showed the motion of living tissues under tremendous magnification and colored illumination. The discussion period was concerned with some of his techniques.

The meeting adjourned at 10:00 P.M.

RAYMOND BRUSH, SECRETARY

MEETING OF MARCH 15, 1960

President Shoumatoff called the meeting to order at 8:00 P.M. in Room 129 of the American Museum of Natural History. The minutes of the previous meeting were approved as read. Messers Whitehead, Schweitzer, Garay, Bast, and Imberman were elected to membership. Mr. Donald Bayne was proposed for membership by Mr. Bryan Treat. The President announced that four meetings of the Junior Society were scheduled for the rest of the season. Mr. Schweitzer, our new member, will speak at the March 26th meet-

ing, Mr. Dix at the April 26th meeting, and on May 7th Dr. Forbes will arrange for the group to visit the Fordham University entomology and biology laboratories. The meeting of May 28th is still open. Dr. Teale related some interesting occurrences at his home in Connecticut; foxes in the moonlight, the appearance of numbers of finches, and the emergence of stoneflies. He read a sonnet which he had written and which had appeared in THE NEW YORK TIMES, "A Naturalist Buys an Old Farm."

Mr. Shoumatoff introduced the speaker of the evening, Dr. Asher Treat, a past-president of the Society and Associate Professor of Biology at City College. Dr. Treat opened his talk, "Invasive Behavior in the Moth Ear Mite" with a poem about a mite by Robert Frost. His talk, accompanied by colored movies, has been prepared for presentation at the International Congress of Entomology to be held in Vienna this summer. (An abstract follows.) A lively discussion period followed.

The meeting adjourned at 9:45 P.M.

RAYMOND BRUSH, SECRETARY

INVASIVE BEHAVIOR IN THE MOTH EAR MITE

Abstract

The Society has heard on earlier occasions that this parasite of the tympanic organs of certain noctuid moths habitually invades only one of its host's ears, leaving the other undamaged and therefore still sensitive to the ultrasonic cries of insectivorous bats. The behavioral basis of this tendency to unilateral infestation is of evolutionary interest because of its high survival value. Various features of the invasion of the host and the establishment of unilateral colonies were photographed during the summer of 1959 and are the subject of a 16 mm., silent, color film prepared for the International Congress of Entomology in Vienna, 1960, and presented in preview at this meeting. Experiments were reported indicating that the path of the first mite from the intertympanic midpoint to either ear of a previously mite-free moth may be experimentally precontrolled by partial denudation of one side of the first abdominal tergum, but that this procedure usually fails if one ear is or has been previously occupied. The possibility is considered that the first mite to arrive leaves a chemical trail from the midpoint to the ear which is to be occupied, and that this trail guides subsequent arrivals.

ASHER E. TREAT

MEETING OF APRIL 5, 1960

The meeting was called to order at 8:00 P.M. by Vice-president Heineman in Room 129 of the American Museum of Natural History. Twenty-three members and seven guests were present. The minutes of the previous meeting were accepted as read. Some of the guests were introduced: Rev. Miguel Fourcade from Uruguay and Mr. C. Antony from India both graduate students at Fordham University, and Prof. Alexander Wolsky, Professor of Experimental Embryology at Fordham. Mr. Donald Bayne was elected to membership. Mr. Michael Mazurkiewicz, an entomology major at Rutgers, was proposed for membership by Mr. D. Whitehead. Dr. Teale read an excerpt

from Holland's **Moth Book** and showed a humorous drawing to illustrate it which was the work of an artist named Chace.

Mr. Heineman then introduced Dr. J. Forbes, Associate Professor of Biology at Fordham, who had arranged the program. He stated that the presentation could be entitled, "Studies in the Anatomy of Ants", and it would be divided into two parts. The first part would be presented by a former graduate student of his and he would give the second part. Brother August Martin McFarlane, F.S.C. was then introduced who spoke on "The Digestive Glands in the Male and the Female Castes of the Black Carpenter Ant." Dr. Forbes explained "A Comparison of the Male Reproductive System in *Camponotus pennsylvanicus*, *Ecton hamatum*, and *Neivamyrmex harrisi*." Both talks were illustrated with lantern slides and were followed by discussions. (Abstracts follow.)

The meeting adjourned at 9:50 P.M.

RAYMOND BRUSH, SECRETARY

THE DIGESTIVE GLANDS IN THE MALE AND THE FEMALE CASTES OF THE BLACK CARPENTER ANT

Abstract

Three pairs of glands are usually associated with the digestive system in ants; the maxillary, the post-pharyngeal, and the labial or salivary glands. These glands are present in the male, the queen, and the three sizes of workers in the black carpenter ant, *Camponotus pennsylvanicus* DeGeer, a polymorphic formicine species.

The size of the maxillary glands and the size of the maxillary gland cells differ in all the forms. They are largest in the queen, and they decrease in size from large-sized worker, medium-sized worker, small-sized worker to the male.

The post-pharyngeal glands, likewise, are largest in the queen. In the workers there is a reduction in gland size from the large-sized to the small-sized worker. In the male this gland is comparable to that in the medium-sized worker.

The salivary glands are well-developed in the three sizes of workers; they have numerous tubules and well-developed reservoirs. In the queen and the male the number of tubules is reduced as is the size of the reservoirs.

The arrangement of the digestive glands in *C. pennsylvanicus* is similar to that in the few forms of other formicine, myrmicine, and ponerine species previously described by other workers.

The maxillary and salivary glands are reported to be lacking in two socially parasitic ants, *Teleutomyrmex schneiderei* and *Anergates atratulus*. It is suggested that the post-pharyngeal glands are utilized for digestion while the maxillary and salivary glands play an important role in trophallaxis.

BROTHER AUGUST MARTIN MCFARLANE, F.S.C.

A COMPARISON OF THE MALE REPRODUCTIVE SYSTEMS IN *Camponotus pennsylvanicus*, *Ecton hamatum*, and *Neivamyrmex harrisi*.

Abstract

The male system in these ants consists of the testes, vasa efferentia, vasa

deferentia, accessory glands and their ducts, the ejaculatory duct, the aedeagal bladder, and the genitalia. Some comparisons are made with this system in the few other species reported.

The testes in these three species are composed of a number of tubules covered with a capsule. This capsule is present in the few other formicine males investigated, but is not present in *Myrmica rubra* nor in *Dorylus labiatus*. The vasa deferentia are either straight or bent tubes; some variation has been reported in those of *D. labiatus*.

The shape and the arrangement of the accessory glands vary. In the formicinae they are large, thick-walled tubes, called the seminal vesicles, and lie between the vasa deferentia. In *D. labiatus* they are similar in shape, but lie lateral to the vasa deferentia. In *Eciton* and *Neivamyrmex* they are coiled, tubular glands situated posterolateral to the vasa deferentia. These latter organs open into the first part of the accessory gland ducts. In the formicinae, myrmicinae, and *Dorylus* the accessory gland ducts are short and combine to form the ejaculatory duct. In *Eciton* and *Neivamyrmex* these gland ducts are bound together with circular muscle fibers, and toward the end of the system their lumina join to form the single ejaculatory duct. In *Eciton* the bound accessory gland duct encircles the ventriculus five or six times. A chitinous wedge is found in the lumen of the ejaculatory duct. This duct, in the three species described and in other formicinae, opens on the posterior, dorsal wall of the aedeagal bladder. This bladder is lacking in the myrmicinae and in *D. labiatus*.

The male system has been described for only a few genera in ants, but each genus reveals interesting differences and modifications.

JAMES FORBES

MEETING OF APRIL 19, 1960

The meeting was called to order by President Shoumatoff in Room 129 of the American Museum of Natural History at 8:00 P.M. Eighteen members and seven guests were present. The minutes of the previous meeting were accepted as read. Mrs. Jane Brower, Mrs. Boker Doyle, and Mr. Richard Applebaum were introduced as guests. Dr. Klots, Chairman of the Field Committee, announced plans for a field trip to be held on Saturday, May 21st, at the Brinton Brook Sanctuary, Harmon, N.Y.; further details at our next meeting. Mr. Michael Mazurkiewicz was elected a member and Dr. Lincoln P. Brower, Mr. Boker Doyle, and Mr. Phillip Granett were proposed for membership. Our President reported that death had claimed another old-time member and past-officer of the Society, Mr. John D. Sherman, Jr., after a long illness and at the age of 87. Mr. Sherman was a well-known entomological book dealer and coleopterist. Until a few years ago he had been active in the affairs of the Society and faithful in his attendance at the meetings.

Dr. Lincoln P. Brower of the Biology Department of Amherst College, the speaker of the evening, was introduced by Mr. Shoumatoff. His topic, "The Ecological Basis for the Origin of Migration in the Monarch Butterfly", was

illustrated with slides and a colored moving picture. He discussed the types of migrations and the habits of the butterfly. An interesting question and answer period followed.

The meeting adjourned at 9:50 P.M.

RAYMOND BRUSH, SECRETARY

MEETING OF MAY 3, 1960

Mr. Heineman, presiding in the absence of Mr. Shoumatoff, called the meeting to order at 8:10 P.M. in Room 129 of the American Museum of Natural History. Fourteen members and four guests were present. The minutes of the previous meeting were accepted as read. Messers Brower, Doyle and Granett were elected to membership. Miss Nancy Oakes was proposed for student membership and Mr. Arthur Maisner was proposed for full membership. Dr. Klots reported the information for the field trip to be held on May 21st, at the Brinton Brook Sanctuary, Harmon, N.Y. and said this would be mailed to the members.

Dr. William F. Barr, the speaker of the evening and an expert on wood-boring beetles, was introduced by Dr. Klots. He opened his talk, "The Biological Control of St. John's Wort in Idaho" with a description of this plant, *Hypericum perforatum*, which is also called goat-weed. It is mildly toxic and detrimental to grazing animals. He described five insects which have been experimented with in this project and told of the successes obtained. The beetle, *Chrysolina gemellata*, has given the best control. A series of color slides illustrating amazing before and after scenes showed conclusively the worth of this type of biological control. A lively discussion period followed.

The meeting adjourned at 9:45 P.M.

RAYMOND BRUSH, SECRETARY

MEETING OF MAY 17, 1960

President Shoumatoff called the meeting to order at 8:05 P.M. in Room 129 of the American Museum of Natural History; twenty-two members and two guests were welcomed by him. The minutes of the previous meeting were accepted as read. Dr. R. W. Hornabrook, a visitor from New Zealand, was introduced. Mr. Sidney Hessel, recently returned from an Ethiopian trip, accepted the chairmanship of the Auditing Committee. Miss Oakes was elected to student membership and Mr. Maisner to full membership. Mr. Richard Applebaum was proposed for membership by the President. He recounted Mr. Applebaum's many accomplishments in entomology. The members approved the suspension of the By-Laws to permit voting immediately on this application for membership because this is the last meeting before our summer recess; Mr. Applebaum was welcomed to membership.

The program of the evening, "Symposium of Members' Activities and Summer Plans", was opened by Lilli Mautner who showed some excellent colored slides she had taken of live insects and spiders. Dr. Klots showed specimens of the primitive and somewhat rare *Eriocrania auricyanea* collected

this spring at Pelham, N. Y. He had slides of larvae and emerging adults of *Lagoa lacyi* collected on a desert oak near Carlsbad, New Mexico, July 1959. Miss White read a four line poem she had written about "bugs". Alice Hopf had a story in the SCIENCE FICTION MAGAZINE titled, "A Great Day for the Irish." This summer she plans to travel in Wyoming and she was advised about getting the proper licenses for insect collecting there. Peter Dix showed a few slides of birds and flowers and a few scenic views taken on his recent European trip. Roman Vishniac showed an ivory carving and ancient Japanese sword guards decorated with an insect motif. He had a figure of a deer, circa 1200 B.C. Greece; all these from his extensive art collection. He said he is awaiting confirmation of a N.S.F. grant to make color moving pictures for high school and college biology courses. Donald Bain showed the exhibits of mounted and classified insects that won for him the Grand Prize at the Dumont, N.J. Science Show. Bryan Treat exhibited some live Cercropia moths and cocoons raised by him. Asher Treat displayed his pet, Kelly—the pseudoscorpion; he told of its eating habits and of its life expectancy. He gave the titles of the papers he will deliver at the entomological congress this summer. Nicholas Shoumatoff showed some slides of flowers, ice-covered trees, and red squirrels he had taken recently on the Appalachian Trail in the Great Smoky Mountains. Raymond Brush expects to collect in Nassau, British Bahamas. Nancy Oakes will raise moths to aid Dr. Teat in his studies of the Moth Ear mite. Richard Applebaum will continue his work with aphids. Paul Watsky will work in the Department of Ornithology at the Museum cataloguing African birds. Jacob Huberman told of the use of Borax in insect pest control. John Schmitt will continue his work on the insect nervous system. Mr. Imberman plans to continue work on fruit fly genetics.

This members' symposium was felt to be most successful and adjourned at 10:00 P.M.

RAYMOND BRUSH, SECRETARY

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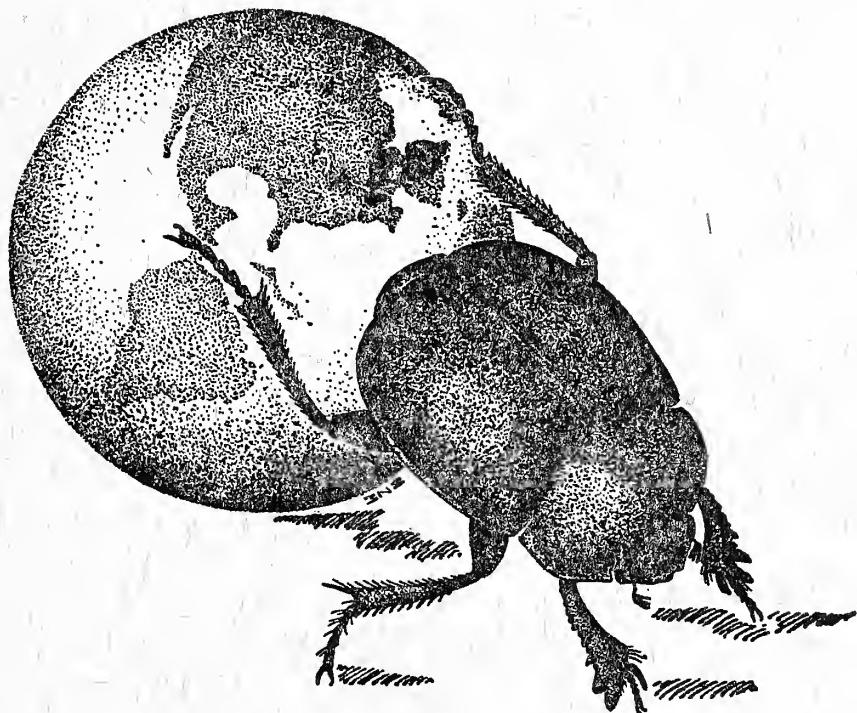
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PURIFICATION AND ACTIVITIES OF PURINE
ENZYMES FROM VARIOUS TISSUES OF THE
AMERICAN COCKROACH *PERiplaneta*
AMERICANA LINNAEUS.
(ORTHOPTERA: BLATTIDAE)

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ABSTRACT

A study was made of the activities of adenosine deaminase, guanase, xanthine oxidase and uricase in homogenates of the foregut, midgut, hindgut, Malpighian tubules and leg muscle of the American cockroach, *Periplaneta americana*. Adenosine deaminase was found in all tissues except leg muscle. Its activity was higher in homogenates of the gut than in those of the Malpighian tubule. Guanase, uricase and xanthine oxidase were present in all tissues. Their activities were highest in the gut and Malpighian tubules, suggesting that these organs play an important role in purine metabolism.

A step in intermediary metabolism of nitrogenous compounds is deamination. An important enzyme in this reaction is adenosine deaminase which breaks down adenosine to inosine. This enzyme was detected by Lennox (1940) in the gut and skeletal muscle of the dipteran *Lucilia cuprina*. Guanine is deaminated to xanthine by guanase. This enzyme has been found by Florkin and Duchâteau (1943) in the water beetles *Hydrophilus* and *Dytiscus*. Lisa and Ludwig (1959) obtained it from fat bodies of the tropical cockroach *Leucophaea maderae*.

Another step in purine metabolism is oxidation. Hypoxanthine and xanthine are oxidized to uric acid by xanthine oxidase. Morgan (1926) found this enzyme in nymphs of various insects. Ross (1959) and Lisa and Ludwig (1959) found xanthine oxidase in the Japanese beetle *Popillia japonica* and the cockroach *Leucophaea maderae*, respectively. Dixon and Lemberg (1934) found that, in purified form, it does not oxidize combined purines. Other enzymes in crude tissue preparations liberate hypoxanthine so that oxidation can take place.

Uricase oxidizes uric acid to allantoin. Ross (1959) found it in newly laid eggs and in larvae of the Japanese beetle, *Popillia japonica*, but was unable to detect it in the prepupa, pupa, or

adult of this insect. Lisa and Ludwig (1959) isolated it from fat bodies of the tropical cockroach.

The present work was undertaken to determine the presence of some enzymes concerned with the intermediary purine metabolism in different tissues of the American cockroach, *Periplaneta americana*. A study was made of the activities of adenosine deaminase, guanase, xanthine oxidase, and uricase in homogenates of the foregut, midgut, hindgut, Malpighian tubules, and leg muscle. These enzymes were obtained in concentrated form and their activities studied.

MATERIAL AND METHODS

The cockroaches were reared in glass jars, at room temperature (about 25°C.). Laboratory food pellets and water were available at all times. Adults, two days after the last molt, were used in all experiments. The digestive tract was removed and subdivided into foregut, midgut and hindgut. Malpighian tubules and leg muscles were also removed. Each portion was cleaned of any debris, and washed several times with ice-cold insect saline solution (Ludwig, Tracey and Burns, 1957), and was studied separately. It was homogenized in the proper buffer and the homogenate was used at a concentration of 100 mg. of tissue per ml. of buffer. In each experiment, except xanthine oxidase determinations, 0.1 ml. of homogenate was used. Controls were treated the same as the reaction mixture, but for determinations of adenosine deaminase, guanase and uricase, 0.1 ml. of boiled homogenate was used, while KCN treated homogenates were used for xanthine oxidase studies.

Enzyme activities were measured with the Beckman DU spectrophotometer. The activity of adenosine deaminase was measured by the method of Kaplan (1955). It is based on the decrease in optical density at 265 m μ when adenosine is deaminated to inosine. Homogenates of the various tissues were made in 0.5 M phosphate buffer at a pH of 7.4. Determinations were made with 2.7 ml. phosphate buffer and 0.2 ml. of adenosine solution and 0.1 ml. homogenate in each of two silica cuvettes (the control contained boiled homogenate). Readings were made at 30 second intervals for 3.5 minutes. Adenosine deaminase from the midgut and hindgut was concentrated by the method of Kalekar (1947a) as modified by Kornberg and Pricer (1951), and the activities of these concentrates were determined.

Guanase activity was studied by the method of Roush and Norris (1950) and is based on the decrease in optical density at $245\text{ m}\mu$ when guanine is deaminated to xanthine. Homogenates were made in 0.5 M tris buffer at a pH of 8.0. In each of two silica cuvettes, 2.7 ml. of tris buffer, 0.1 ml. of guanine, and 0.1 ml. of homogenate were placed. Readings were made at 30 second intervals for three minutes. Guanase was purified from the hindgut and Malpighian tubules by the method of Kalckar (1947b) and assayed by the method of Roush and Norris (1950).

The activity of uricase was studied by the method of Schneider and Hogenboom (1952). It is based on the decrease in optical density at $290\text{ m}\mu$ when uric acid is oxidized to allantoin. Homogenates were prepared in 0.5 M phosphate buffer at a pH of 7.4. To each of two silica cuvettes, 2.6 ml. of water, 0.2 ml. of phosphate buffer, 0.1 ml. of uric acid, and 0.1 ml. of homogenate were added. Readings were made at one minute intervals for five minutes. Uricase was purified from the hindgut and Malpighian tubules according to the methods of Leone (1953) and of London and Hudson (1956). It was assayed by the method of Schneider and Hogenboom (1952).

The activity of xanthine oxidase was determined by the method of Horecker and Heppel (1949). It is based on the change in density at $550\text{ m}\mu$ as cytochrome *c* is reduced by the oxidation of hypoxanthine to uric acid. Homogenates were made in 0.1 M phosphate buffer at a pH of 7.4. In each of two corex cuvettes were placed 2.0 ml. of phosphate buffer, 0.1 ml. of 2.5×10^{-4} M cytochrome *c*, 0.1 ml. of catalase, 0.1 ml. of bovine albumin, and 0.1 ml. of water. Then 0.4 ml. of fresh homogenate was added to the reaction mixture and 0.4 ml. of KCN treated homogenate to the control. Readings were taken at one minute intervals for 7 minutes after the mixtures were combined with 0.1 ml. of 0.05 M hypoxanthine. Then 1 mg. of solid $\text{Na}_2\text{S}_2\text{O}_4$ was added and a final reading was made. Calculation of enzyme activity were made using the formula of Horecker and Heppel 1949. Xanthine oxidase was concentrated by the method of Horecker and Heppel (1949) from the hindgut and Malpighian tubules and its activity measured.

OBSERVATIONS

Table I contains average values for ten determinations of the

activities of adenosine deaminase, guanase, and uricase in tissue homogenates and five determinations for concentrated adenosine deaminase, guanase, and uricase. For each enzyme, activity of the gut was greater the more posterior the region selected for the determination. The activity of adenosine deaminase was greatest in the hindgut. Malpighian tubules showed less activity than the gut, and no activity was found in the muscles. Guanase activity was detected in all the tissues studied. It was greatest in the

TABLE I.

Activities of adenosine deaminase, guanase, and uricase in various tissues of the cockroach. Activity is expressed as μg . of substrate converted by 1 ml. of homogenate per hour.

Tissue	Adenosine deaminase	Guanase	Uricase
Foregut	7.2	6.6	3.6
Midgut	7.4	11.6	19.2
Hindgut	7.5	12.2	33.6
Malpighian tubules	3.8	14.6	30.0
Leg muscle	0.0	11.0	6.0
Concentrated enzyme	8.1	22.4	43.2

TABLE II.

Activity of xanthine oxidase, expressed as moles of cytochrome *c* reduced per ml. of homogenate per hour.

Tissue	Activity
Foregut	0.189
Midgut	0.191
Hindgut	0.348
Malpighian tubule	0.702
Leg muscle	0.094
Concentrated enzyme	4.242

Malpighian tubules. Uricase activity was also found in all of the tissues studied but its activity was greatest in the hindgut. In each case, the concentrated enzyme showed an increased activity over that of the tissue homogenates.

The activities of xanthine oxidase in various tissues are given in Table II. The enzyme from the Malpighian tubules was most active. The concentrated enzyme showed a greatly increased activity over that of the tissue homogenate.

DISCUSSION

Brown and Farber (1936) assumed that deamination of adeno-

sine in the blow flies *Lucilia sericata* and *Calliphora erythrocephala* occurs mostly in the tissues of the hindgut and midgut. They observed that the addition of intestinal extract as a substrate has a short stimulating effect on deamination of breakdown products of the proteins. These end-products become substrates for deamination which may take place in the cells of the posterior segment of the midgut or in the hindgut. This observation is corroborated by the present work, since the deaminase was found most active in the tissues of the midgut or hindgut.

There is a possibility that guanine is converted to xanthine as soon as it is formed since guanine has not been detected in insect tissue. The present work indicates that the gut, Malpighian tubules and leg muscles are probable sites for this reaction. These results are in agreement with those of Anderson and Patton (1955) who also found guanase in the gut and fat body of *Periplaneta americana*, *Prodenia eridana* and *Tenebrio molitor*.

The distribution of uric acid in different insects has been fairly well established but its oxidation to allantoin has not been generally accepted. Investigators have indicated that the principal sites for this activity are the Malpighian tubules and the fat body. Brown (1938a and b) stated that the nitrogen metabolism in the blow fly, *Lucilia sericata*, is through uric acid which is present in various stages of the life cycle and is oxidized to allantoin except in the prepupa and pupa. This work was confirmed by Ross (1959) who detected uricase in the newly laid eggs and larvae of the Japanese beetle *Popillia japonica*, but was unable to find it in the prepupa, pupa or adult. Lisa and Ludwig (1959) studied uricase from the fat body of nymphs and adults of the cockroach, *Leucophaea maderae*, and found that its reaction is of the first order with a Michaelis constant of 1.7×10^{-5} moles per liter. This figure is in general agreement with that obtained for uricase in mammalian tissue. The present work is an extension of their findings since uricase was detected in all the tissues studied.

Allantoin, the product of uric acid oxidation, has been detected in other insect tissues. It was found in the wings of Pieridae by Schöpf (1939). Ludwig and Cullen (1956) found both uric acid and allantoin in the blood of the Japanese beetle. These findings were corroborated by Heller and Szarkowska (1957) who found

uric acid in the blood of the moths, *Celerio euphorbiae* and *Sphinx pinastri*. Leifert (1935) found uricase in the pupa of the moth, *Antheraea pernyi*. Rocco (1938) found it in the carnivorous beetles of the families Dytiscidae and Carabidae, and in various Orthoptera. Truskowski and Chajkinowa (1935) found it to be very active in the adult muscid flies but absent in the German cockroach *Blatella germanica*, in the beetle *Melolontha*, in the bee *Apis mellifica* and in aphids.

Very little is known of the organs concerned with the formation of nitrogenous waste products, or of their chemistry. Although it has been stated by Leifert (1935), and by Anderson and Patton (1955), that the site for purine metabolism is the fat body, the present work indicates that the gut and the Malpighian tubules also play an important role since all of the enzymes studied were detected in these tissues.

SUMMARY

1. Adenosine deaminase from the foregut deaminated 7.2, the midgut 7.4, the hindgut 7.5, and the Malpighian tubules 3.8 micrograms of adenosine per ml. of 0.1 per cent homogenate per hour. No activity was found in the muscle. The activity value for concentrated enzyme was 8.1 micrograms per ml. of enzyme preparation per hour. Corresponding values for guanase were 6.6, 11.2, 12.2 and 14.6, respectively. This enzyme from muscle converted 11.0 micrograms of guanine per ml. of 0.1 per cent homogenate per hour. The activity value for purified enzyme was 22.4.

2. Uricase from the foregut oxidized 3.6, the midgut 19.2, the hindgut 33.6, the Malpighian tubules 30.0 and the leg muscles 6.0 micrograms uric acid per ml. of 0.1 per cent homogenate per hour. The corresponding figure for the concentrated enzyme was 43.2.

3. The activity of xanthine oxidase, expressed in moles of cytochrome *c* reduced per ml. per hour, were foregut 0.189, midgut 0.191, hindgut 0.348, Malpighian tubules 0.702, and leg muscle 0.094. The corresponding value for the purified enzyme was 4.242.

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**UNDESCRIPTED SPECIES OF CRANE-FLIES
FROM THE HIMALAYA MOUNTAINS
(DIPTERA: TIPULIDAE), VIII***

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ABSTRACT

The following new species are defined: *Gonomyia (Progonomyia) bisiculifera*; *G. (P.) protensa*; *G. (Gonomyia) tanaocantha*, from Sikkim; *G. (Lipophleps) kama*; *G. (L.) varsha* from Kumaon and West Bengal, and *G. (L.) mizoensis* from the Lushai Hills, Assam.

The preceding part under this general title was published in the *Journal of the New York Entomological Society*, **70**: 10-16; 1962. As was the case in all recent parts the materials were included in vast series of these flies collected by Dr. Fernand Schmid, collections so rich as to have virtually doubled the number of species of these flies previously known from India. My deep thanks again are extended to Dr. Schmid for the privilege of studying this important series. The types of the new species are in my personal collection of Tipulidae.

***Gonomyia (Progonomyia) bisiculifera* new species**

Size medium (wing of male about 5.5 mm.); mesonotal praescutum and scutum polished black, posterior sclerites and the pleura more pruinose, scutellum darkened; knobs of halteres whitened; legs black, fore femora narrowly yellowed at bases; wings grayish white, beyond cord more darkened,

* Contribution from the Entomological Laboratory, University of Massachusetts.

with a still darker band at cord; male hypopygium with outer apical angle of basistyle extended into a broad plate; two dististyles, the inner including a heavy blackened blade and two outer slender spines from a short common base; apex of aedeagus produced into a spine.

MALE Length about 6 mm.; wing 5.6 mm.; antenna about 1.2 mm.

Rostrum and palpi black. Antennae black; flagellar segments very strongly produced beneath, narrowed into apical pedicels, outer segments gradually more slender; verticils very conspicuous, those on outer face at base longer than the segments. Head gray.

Pronotum black, the pleura more polished. Mesonotal praescutum and scutal lobes intense polished black, midregion of suture more yellowed; posterior sclerites of mesonotum, including the midregion of scutum, black, gray pruinose; posterior border of scutellum vaguely paler. Pleura black, surface very slightly dulled by pruinosity, sternopleurite more polished; dorsopleural region and conspicuous membrane behind the propleura whitish yellow, meral region more obscure yellow. Halteres with stem infuscated, knob whitened. Legs with coxae black, posterior pair more pruinose; trochanters black; remainder of legs black, fore femora narrowly yellowed basally. Wings grayish white before cord, weakly infuscated beyond, more evidently so outwardly; a darker brown band from stigma over the cord; veins brownish black. Macrotrichia on longitudinal veins beyond general level of origin of Rs , more sparse on 1st A . Venation: Sc very long, Sc_1 ending about opposite six-sevenths the long Rs ; R_{2+3+4} and R_{3+4} subequal, both a little longer than R_2 ; cell 2nd M_2 about one-half longer than its petiole; $m-cu$ about two-thirds its length beyond the fork of M .

Abdomen, including hypopygium, black. Male hypopygium with outer apical lobe of basistyle a broad flattened plate or flange, its outer end short pointed, surface with setae. Dististyles complex; outer style a yellow blade narrowed to the obtuse tip; inner style distinctive, black, including a broad inner blade and a narrow outer one that forks just beyond base into two slender slightly unequal spines, both acutely pointed at tips; outer spine slightly more slender, surface microscopically roughened. Aedeagus broad, the apex narrowed into an acute spine.

HOLOTYPE, ♂, Yugang, Sikkim, 5700 feet, May 14, 1959 (Schmid).

Gonomyia (Progonomyia) bisiculifera is generally similar to *G. (P.) protensa* new species, differing conspicuously in the structure of the male hypopygium, particularly the spine of the basistyle, dististyles and aedeagus. These two flies are the first members of the subgenus *Progonomyia* Alexander to be discovered in India. In both species the basal attachment of the dististyles is peculiar, apparently being interconnected at base and attached to condyles at the inner apical angle of the basistyle. In this regard these flies differ from the more normal condition found in the Neotropical and South African species of the subgenus.

Gonomyia (Progonomyia) protensa new species

Size relatively small (wing of male 4.5 mm.); mesonotal praescutum and scutal lobes polished black, the posterior sclerites more pruinose, scutellum and dorsopleural membrane light yellow; knobs of halteres pale yellow; legs black, fore and middle femora paler basally; wings with cells before cord whitened, outer cells more suffused, stigma and a seam over cord darker brown; R_2 present; abdomen black; male hypopygium with outer apical angle of basistyle produced into a slender spine; two dististyles, the inner one blackened, biramous.

MALE Length about 5.5 mm.; wing 4.5 mm.; antenna about 1.2 mm.

Rostrum shiny black; palpi black. Antennae black throughout; proximal flagellar segments suboval, the lower face more produced; outer segments long-oval, all flagellar segments with long conspicuous verticils. Head gray.

Pronotum black, pretergites yellow. Mesonotal praescutum and scutal lobes uniformly polished black, central region of scutum broadly gray pruinose, point of the V-shaped suture obscure yellow; scutellum light yellow, parascutella black; mediotergite black, surface slightly opaque by a vague bloom. Pleura and pleurotergite polished black, dorsopleural membrane broadly light yellow; dorsal part of meron and the metapleura restrictedly yellowed. Halteres with stem blackened, knob very pale yellow. Legs with coxae black; trochanters brownish black; remainder of legs black, the proximal fourth or fifth of fore and middle femora brownish yellow. Wings with cells before cord chiefly whitened, beyond this chiefly weakly darkened, the bases of the cells slightly paler; stigma and a conspicuous seam over cord darker brown; veins dark brown, prearcular veins slightly paler. Veins beyond general level of origin of Rs with conspicuous macrotrichia, including also the outer third of 1st A and most of 2nd A . Venation: Sc long, Sc_1 ending shortly before fork of Rs , Sc_2 far retracted; vein R_2 preserved, as in the subgenus; R_{2+3+4} and R_{3+4} subequal; cell 2nd M_2 subequal to its petiole; $m-cu$ from two-thirds to three-fourths its length beyond fork of M .

Abdomen polished black, segments eight and nine slightly paler. Male hypopygium with outer apical angle of basistyle produced into a long slender spine, near its base with several very long setae. Two dististyles, the outer a flattened yellow blade that narrows gradually to the obtuse tip; inner style blackened, biramous, including a large outer sickle-shaped structure that narrows to the acute tip and a shorter inner arm that is very unequally bispinous. Aedeagus with tip subacute; surface with few but very long setae.

HOLOTYPE, ♂, Manu, Sikkim, 4920 feet, May 10, 1959 (Schmid).

In its general appearance, *Gonomyia (Progonomyia) protensa* is very similar to the larger *G. (P.) bisiculifera*, differing conspicuously in hypopygial structure.

Gonomyia (Gonomyia) tanaocantha new species

Allied to *multiacuta*; mesonotum dark brown, variegated with yellowish brown; legs brownish black; wings with Sc_1 ending about opposite one-

third Rs ; male hypopygium with spine of inner dististyle very long; aedeagus elongate, terminating in two small recurved spines.

MALE Length about 4.5 mm.; wing 5.2 mm.

Rostrum dark brown; palpi black. Antennae with scape and pedicel brownish black; flagellum broken. Head dark gray.

Pronotum yellow. Mesonotal praescutum and scutal lobes chiefly dark brown, paler laterally; central region of scutum, scutellum, sides of mediotergite and pleurotergite yellowish brown. Pleura obscure yellow, more darkened on anepisternum and less evidently on ventral sternopleurite. Halteres with stem obscure yellow, knob destroyed by insect pests. Legs with fore coxae dark brown, middle pair less darkened on anterior face, remainder of coxae yellow; trochanters yellow; remainder of legs brownish black. Wings weakly tinged with brown, prearcular and costal fields more yellowed; stigma pale brown; veins darker brown, paler in the brightened fields. Macrotrichia on longitudinal veins beyond general level of origin of Rs , lacking on about the basal third of Sc , narrow bases of M and 1st A , present on outer third or less of basal section of Cu_1 and 2nd A . Venation: Sc relatively long, Sc_1 ending about opposite one-third Rs , Sc_2 faint, placed near tip; R_{2+3+4} only a little longer than R_3 ; $m-cu$ far distad, about three-fourths its length beyond fork of M .

Abdomen dark brown, hypopygium slightly paler. Male hypopygium generally as in *multiacuta*, but with various structures extended, notably the inner dististyle and aedeagus. Tergal plate conspicuous, subquadrate in outline, posterior border slightly concave, lateral angles and sides with dense coarse setae. Basistyle with apical lobe small. Outer dististyle a darkened blade, constricted beyond base, widest at midlength, thence narrowed to an acute point; lower surface with abundant delicate erect setae; inner style with body short and obtuse, the fasciulate setae very long; darkened spine on face of style long-extended into a blackened rod, before apex on outer margin with a single strong recurved bristle. Phallosome including symmetrical gonapophyses at base, narrowed outwardly into acute points, decussate at midlength; aedeagus elongate, terminating in two small recurved spines.

HOLOTYPE, ♂, Chumtang, Sikkim, 5120 feet, July 18, 1959 (Schmid).

Although it obviously is allied to *Gonomyia* (*Gonomyia*) *multiacuta* Alexander, the present fly is quite distinct in the structure of the male hypopygium, especially the dististyles and aedeagus.

Gonomyia (Lipophleps) kama new species

General coloration of mesonotum brownish gray, scutellum broadly obscure yellow; pleura dark brown, with a conspicuous white longitudinal stripe; femora obscure yellow with a brownish black subterminal ring; wings weakly darkened, with vague paler areas on disk, Sc short; abdominal tergites dark brown, their posterior borders obscure yellow; male hypopygium with two terminal dististyles, the outer blackened, bifid; apical fasciulate bristles of inner style very short; phallosomic complex including paired needlelike spines.

MALE Length about 3.5 mm.; wing 3.9–4.2 mm.

FEMALE Length about 4.5 mm.; wing 4.8–5 mm.

Rostrum and palpi black. Antennae brownish black, scape and pedicel above light yellow; flagellar segments elongate, with very long verticils. Head yellow, vertex patterned with brown.

Pronotum and pretergites light yellow. Mesonotal praescutum and scutum almost uniformly brownish gray, posterior margin of scutal lobes yellowed, pseudosutural foveae reddish brown; scutellum broadly obscure yellow, narrowly darkened medially at base; mediotergite dark gray, pleurotergite yellowed. Pleura dark brown, pruinose, dorsal pteropleurite more yellowed; a broad conspicuous whitened longitudinal stripe extending from and including the fore coxae to the base of abdomen. Halteres light yellow, base of knob more infuscated. Legs with coxae pale yellow, fore pair more whitened, base narrowly more darkened; trochanters yellow; femora obscure yellow with a brownish black subterminal ring, the pale tip narrow; tibiae brownish yellow, tarsi passing into black. Wings weakly darkened, stigma oval, pale brown; prearcular and costal fields light yellow; vague paler areas on disk, especially before and beyond cord, before and beyond stigma and in the Anal cells; veins brownish yellow, cord darker, veins in costal field clearer yellow. Most longitudinal veins beyond cord with macrotrichia, lacking on anterior branch of *Rs*. Venation: *Sc* short, *Sc₁* ending some distance before origin of *Rs*, branches of the latter strongly divergent, cell *R₃* at margin very extensive.

Abdominal tergites dark brown, posterior borders obscure yellow, narrowly interrupted at the midline; sternites brownish yellow medially, darker on sides; outer segments more uniformly brownish black; hypopygium ferruginous, especially beneath. Male hypopygium with the basistyle stout. Two dististyles, the blackened outer style bifid near base into a long slender outer arm and a strong basal spine; margin of longer arm with appressed spinules, more abundant near apex; inner style simple, slightly narrowed outwardly, apex truncate and bearing two unusually stout fasciculate bristles or spines, with additional normal setae on outer half of style. Phallosome unusually complex, including elements as follows: two lateral apophyses that extend caudad into subhyaline needlelike spines, at base of mesal margin with a shorter curved arm that narrows to an acute point; a further complex central sclerotized scaffolding.

HOLOTYPE ♂, Sutol, Pauri Garhwal, Kumaon, 7250 feet, August 18, 1958 (Schmid). Allotype, ♀, Kanol, Pauri Garhwal, 8530 feet, August 19, 1958. Paratypes, ♂♂♀♀, with the allotype; other ♂♂♀♀, Dhar, Pauri Garhwal, 7220 feet, August 17, 1958; Taproban, Pauri Garhwal, 7300 feet, July 28, 1958; Tarak Tal, Pauri Garhwal, 7540 feet, August 14, 1958 (all Schmid).

Gonomyia (Lipophleps) kama is generally similar to *G. (L.) flavomarginata* Brunetti and a few regional allies, differing from all in the hypopygial structure.

***Gonomyia (Lipophleps) mizoensis* new species**

Allied to *diacantha*; general coloration of mesonotal praescutum and

scutum brownish black, sparsely pruinose, scutellum broadly yellow; pleura conspicuously striped longitudinally with brown and white; legs brownish black; wings grayish, base and costal region more yellowed, disk with extensive slightly darker clouds; Sc short, basal section of R_5 elongate; male hypopygium with outer dististyle strongly bispinous at base, inner style terminating abruptly in a blackened spine; phallosome chiefly pale, broadly transverse, lateral blades each bearing two small blackened points.

MALE Length about 4.5 mm.; wing 3 mm.

Rostrum and palpi black. Antennae black, dorsal face of scape obscure yellow; basal flagellar segments very long and slender, verticils very long, as in the subgenus. Head light yellow, disk of posterior vertex with a broad brown subtriangular area.

Pretergites and dorsal pronotum light yellow, cervical region and sides of pronotum brown. Mesonotal praescutum and scutum brownish black, sparsely pruinose, humeral region very restrictedly obscure orange; pseudosutural foveae polished dark brown; central region of scutum vaguely yellowed; scutellum yellow, darkened at base; postnotum brown posteriorly, base obscure yellow, being a continuation of a long pale pleural stripe. Pleura pale brown, above bordered by the pale yellow dorsopleural region, beneath by a pale yellow longitudinal stripe, beginning on fore coxae; ventral sternopleurite and meron purplish brown. Halteres with stem and base of knob medium brown, remainder of knob light yellow. Legs with coxae yellow, bases of mid pair very narrowly darkened; trochanters darkened anteriorly, more yellowed behind; remainder of legs brownish black; posterior femora with a series of erect elongate setae. Wings grayish, base and costal border light yellow; stigma pale brown, preceded and followed by light yellow areas; extensive slightly darker brown clouds, chiefly in cells R and M , at anterior cord and in outer radial field; veins pale brown, scarcely brighter in the costal field. Veins R_5 , M_{1+2} and M_3 with macrotrichia. Venation: Sc short, Sc_2 close to tip of Sc_1 , distance on margin between Sc_1 and origin of Rs nearly equal to Rs , branches of the latter divergent; basal section of R_5 long; $m-cu$ shortly before fork of M .

Abdominal tergites and hypopygium brown, sternites paler. Male hypopygium with dististyles terminal; outer style a stout blackened rod, apex obtuse, on face of rod beyond midlength with about four microscopic spines; inner margin of basal half produced into two stout spines, the outer one much stouter; inner style a simple stout yellow rod, apex abruptly narrowed into a blackened spine. Phallosome complex in structure, entirely different from that of *diacantha*; transverse, with lateral flattened disks each of which bears two small blackened points, the inner one an acute spine; inner arm of either side produced into a pencil of long yellow bristles.

HOLOTYPE ♂, Thingsat, Lushai Hills, Mizo District, Assam, 2000 feet, September 9, 1960 (Schmid).

The most similar regional species is *Gonomyia (Lipophleps) diacantha* Alexander, of Mindanao, which differs evidently in the hypopygial structure, especially the phallosome. *G. (L.)*

flavomarginata Brunetti still is insufficiently known to me. The additional notes on type material, as given by Edwards (Rec. Indian Mus., 26: 301; 1924), indicate a species distinct from the present fly.

Gonomyia (Lipophleps) varsha new species

Size small (wing of male 3.5 mm.); mesonotum brown, scutellum broadly yellow; thoracic pleura brown with a conspicuous yellowish white longitudinal stripe; femora brownish yellow with a vague darker subterminal ring; wings weakly suffused, variegated with yellow; Sc short; abdominal tergites dark brown, their posterior borders paler; male hypopygium with outer dististyle profoundly bifid.

MALE Length about 3.2 mm.; wing 3.5 mm.

FEMALE Length about 4–5 mm.; wing 4–5 mm.

Rostrum and palpi black. Antennae with scape and pedicel darkened beneath, light yellow above, flagellum brownish black; flagellar segments elongate, the more proximal ones with the usual very long verticils. Head light yellow, vertex extensively dark brown.

Pronotum light yellow, scutellum medially weakly infuscated; pretergites conspicuously light yellow. Mesonotum brown, tuberculate pits and pseudosutural foveae brownish black; scutum brownish gray, scutellum clear light yellow, brownish gray medially at base; postnotum brown, variegated by obscure yellow. Pleura brown, lighter brown above; a conspicuous yellowish white longitudinal stripe from and including the fore coxae, extending to base of abdomen, narrowly bordered both above and beneath by slightly darker. Halteres light yellow, base of knob infuscated. Legs with fore coxae pale yellow, remaining coxae pale yellow, narrowly darkened basally; trochanters yellow; femora brownish yellow with a vague slightly darker subterminal ring, the actual tip narrower, obscure yellow; tibiae obscure yellow, tips narrowly infuscated; basitarsi brownish yellow, outer segments dark brown. Wings weakly suffused, prearcular and costal fields clearer yellow; vague pale areas before and beyond stigma and elsewhere on disk; veins pale brown, slightly darker along cord, yellowed in the brightened fields. Rs and its anterior branch glabrous, R_5 and outer medial branches with trichia. Venation: Sc short, Sc_1 ending a distance before origin of Rs about equal to one-half this vein; basal section of R_5 long; base of cell 1st M_2 unusually broad; $m-cu$ at fork of M .

Abdomen dark brown, posterior borders of segments slightly paler; sternites and hypopygium brownish yellow. Male hypopygium with basistyle relatively small, the mesal face with numerous setae, some long. Two terminal dististyles; outer blackened, profoundly bifid into two subequal arms, outer arm stout on basal two-thirds, the slightly bent outer part a straight spine, surface with microscopic oval areas or reticulations; inner arm strongly bent at basal third, thence arcuated and narrowed to the truncated apex; inner style elongate, with strong setae on outer half, including two closely approximated fasciculate bristles at apex. Phallosome including a pair of flattened yellow blades that bear a strong appressed

spine on lower margin, tip blackened, acute; unpaired central mass generally pale, hyaline outwardly, produced into a strong black spine.

HOLOTYPE ♂, Pagna Malla, Pauri Garhwal, Kumaon, 5955 feet, August 11, 1958 (Schmid). Allotopotype, ♀, pinned with type. Paratypes, 1 ♂, 1 ♀, Git Dabling, West Bengal, 5100 feet, September 13, 1959 (Schmid).

The most similar regional species include *Gonomyia (Lipophleps) lanka* Alexander and *G. (L.) nexosa* Alexander, which likewise have the outer dististyle of the male hypopygium profoundly bifid but which differ in all other details of structure, including both dististyles and the phallosome.

COMMUNICATION AMONG STINGLESS BEES— ADDITIONAL DATA (HYMENOPTERA: APIDAE)¹

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ABSTRACT

A brief report on bee communication research between 1953 and 1962 is presented. Additional data included in this paper show: 1. more than twice as many bees are necessary to dehydrate syrup (50% sugar) collected by 40 bees; 2. two species called *Trigona (Scaptotrigona) postica* could not cross in nature and one had a different mandibular gland odor; 3. different methods (3) were used to demonstrate that the "scent-path" used by marking Trigonas has polarity, being more intense nearer the food source; 4. scent marking of bees is retained for an average of 9 minutes in *T. (T.) spinipes* and 14 minutes in *T. (S.) postica* and *T. (S.) bipunctata* subsequent to deposition in the scent-path; 5. a worker of *T. (S.) xanthotricha* fol-

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⁵ Submitted for inclusion in the **Herbert F. Schwarz Memorial Volume** (1962) but delayed in publication due to lack of space, cf, 70 p. 214.

lowed a scent path for the first time when 51 days old, marked her own scent-path when 55 days old, 10 and 15 days respectively after her first forage, and 6. species phylogenetically distant cannot follow extra-specific scent-paths whereas closely related species can.

The returning foragers of the honeybee *Apis mellifera* Linné perform a special dance in front of their nest mates and induce them to find the food source. This foraging dance has been referred to by Aristotle. Although its significance as a communication dance, first suggested by Spitzner (after Ribbands 1953), was confirmed by v. Frisch after 1920. Thereafter, v. Frisch (1923-1955) and his school clarified the significance and efficiency of the foraging dance. The first comparative study of this nature was given for the Apinae, namely, *Apis florea* Fab., *A. dorsata* Fab., *A. cerana indica* Fab., *Trigona (Tetragonula) iridipennis* Smith.

In the present paper, our further studies in Rio Claro are described, together with some preliminary work undertaken by W. E. Kerr in Piracicaba.

Our main aim in the study of meliponid biology, in 1953, was to find out whether they do or do not have a sign of communication. To demonstrate this the experiments 1, 2, 3 and 4 were executed; experiments 5 and 6 were done to increase the number of species so far observed and experiments 7, 8, 9 and 10 were done to clarify details of the bee system of communication.

1. Can workers of *Trigona (Nannotrigona) testaceicornis* Lepeletier communicate between themselves?

On February 2, 1953, a petri dish with syrup was left through the daytime 4m from a hive. No bee was attracted. On the next day at 5.40 P.M. one worker was trained to collect syrup in a food source at the same distance. At 6.10 P.M. two other workers arrived; at 6.15 P.M. one more, and at the end of the day 11 new arrivals were counted. By marking them with paint it was proved that all of them belonged to the same hive and no bee of the neighbor colonies was attracted. In this simple way it was first proved that the stingless bees had some means of communication.

2. Is there communication among workers of *Melipona quadri-fasciata* Lepeletier?

The above experiment was repeated with workers of *M. quadri-*

fasciata on February 6 and 7, 1953, and it was verified that they can also communicate the occurrence of a food source. The test colony was put in the office of W. E. Kerr and the following events were recognized:

a. The returning bees produce a noise after entering the hive. When the food source was put at 12m from the hive the bees produced 18 buzzes in 10 seconds. A bee collecting pollen from a palm tree 100m from the hive buzzed about 5 times in 10 seconds, while one collecting food 850m did not buzz. This suggests a probable correlation between frequencies of piping and distances as in *Apis* between frequencies of dances and distances. Further crucial experiments are now under way. Lindauer and Kerr (1958, 1960) proved that this buzzing is a method of alarm.

b. The bees alighting at the food source also produce a noise the significance of which is still unsolved.

c. The bees looking for the food source (52m apart from the hive) communicated erratically. Deviations of more than 5m from the correct food source occurred. The direction was, however, quite reasonable. No bees went to the place which deviated 180° from the correct food source.

d. Bees loaded with syrup entering the hive deliver it to the receivers. The entrance tube was 35cm long and the receivers are located both within the tube or 4cm apart from the tube within the hive.

e. When the number of bees intensely collecting syrup (50% sucrose solution) reached 40, there were about 90 bees dehydrating. The collecting from the food place ceased at 6.28 P.M. The dehydration was still intense until 9.00 P.M.; decreased about 10.00 P.M. and finished at 11.00 P.M.

3. Is there communication among workers of *Trigona (Plebeia) schrottkyi* Friese?

A bee of this species was trained at a place 25m from the hive, on August 10, 1953. One marked bee reached the right distance at 11.00 A.M. At 1.00 P.M. two more bees arrived and at 3.00 P.M. there were 12 other bees from the same hive. This is a slow, primitive bee, but it is clear that she possesses communication devices.

4. Application of the Françon method.

In order to detect ability to communicate in some species we

tried to use the method of Françon (1939) to train the bees to artificial food places. The method consists of imprisoning a bee on a flower, within a glass turned upside down on a plate where a drop of syrup is put. When the bee becomes calm and begins to take food, the glass is removed. On January 5, 1954, we tried this method with *Melipona favosa*, *M. marginata*, *Trigona postica*, *T. hyalinata*, *T. spinipes* (= *T. rufifcrus*). The method worked well for the last two but not in the others. For *T. spinipes* the method worked so nicely that we could work with bees collected by wings on *Alloe* sp. flowers; very often even while being held by the wings the bees began to take syrup.

On January 6, 1954, this experiment was repeated with *T. (T.) hyalinata*. When the bees are collecting nectar of high sugar content they never come back to the plate. But from bees visiting flowers with only 20% sugar content good results were obtained. One bee collected on *Alloe* flowers and fenced to the plate came back to the latter at 2.16 A.M. She alighted again on the plate and left quickly. Two new comers alighted at 2.26 P.M. 22 bees were on the plate at 2.30 P.M. The precision of the communication of this species astonished us. The same experiment with *T. (T.) spinipes* gave similar results. Lindauer and Kerr (1958, 1960) showed that some superior trigonas, for instance, *T. spinipes*, *T. postica*, *T. capitata* have a precise communication system, leaving a scent-path from the food source to the hive which is followed by new-comers. Later Kerr observed the same type of communication in *T. hyalinata*.

5. Communication among other *Scaptotrigona*.

After the experiments of Lindauer and Kerr (1958, 1960) we decided to complete these observations for other bees. As *T. (Scaptotrigona) postica* revealed itself one of the species with the best communication system, we decided to compare other species of the same subgenus.

Trigona (Scaptotrigona) paraense n. sp. (Kerr, in manuscript)

We received a hive of this species from Rio Formoso, Pará, Brazil, through the kindness of Dr. D. Dias. This bee, except for the slightly larger body size and the more dense black coloration is so similar to *T. postica*, that Prof. J. S. Moure is of the opinion that it is a mere subspecies of *T. postica* (as far as the morphological characters alone are considered). However, we find that a virgin queen, which made several nuptial flights

could not mate with the hundred males of *T. postica* of which we had 4 hives within 200m. Moreover, no *postica* male was attracted by the queenless *paraense* hive, as is common when both hives belong to the same species: therefore they are considered two distinct species. We trained four bees 4m far from the hive on October 3, 1957; no scent marking occurred. The distance between the food and the hive was gradually increased at about hourly intervals. The bees commenced scent marking on the ground only when the food place reached 15m from the hive (for *T. (S.) postica* the threshold distance is between 11 and 12m). The smell of a smashed head was quite different from that of *T. postica*, that of *paraense* more "carnation-like."

Trigona (Scaptotrigona) filosofai Kerr (in manuscript)

A hive of this bee came from Campinas, Goiaz, near Rio Formoso where *T. (S.) paraense* was collected. The workers are smaller and more yellow than those of *postica* and the virgin queens were unable to mate with the males of *T. postica* suggesting strongly its heterospecificity to the latter species. The communication experiment was made on October 1, 1957. The scent was more like that of *postica* than in *T. paraense*. The workers began to mark at 9m from the hive. The distances between markings were shorter than those in *postica*.¹

6. Is there communication among *Trigona (Trigona) amalthea*?

The hive of *Trigona amalthea* (= *T. trinidadensis*) was in a cavity of the trunk of *Eucalyptus* at 9m above the soil surface. The bees were trained to feed on filter paper containing 50% sugar solution. It was a "slow" bee: 4 days were required to complete the experiment which was completed on July 9, 1959. The scent of the mandible gland of this species is similar to that of *T. hyalinata* or *T. spinipes*. The experiment resulted in the following conclusions:

- a. The communication system of this species is by scent paths.
- b. The scout bee began scent marking between 26 to 30m from the hive. Even though the food source remained 26m from the hive during a full day, the bees did not mark.
- c. Distances between two marks varied considerably. Within the first 5m several marks were left (the feeding table itself

¹ These preliminary experiments were performed while W. E. K. served in Piracicaba, the following were carried out in Rio Claro.

received 11 scent marks). Thereafter the marks made averaged 15m. This indicates a non-uniform scent path, and suggested that we look to other arguments favoring polarity.

7. Is there a polarity in the scent path made by marking bees of *Trigona (S.) postica*?

Two experiments were performed to determine whether or not a differential gradient exists between scent marks, that is, a gradient in the scent path from food source to hive left during communication by workers of the superior *Trigonas*.

The first experiment studied two colonies, A and B, of *Trigona (Scaptotrigona) postica*, located 35m apart from each other (Fig. 1). One marked bee of hive A was trained to feed at the source C placed on the line connecting A and B, and 24m from

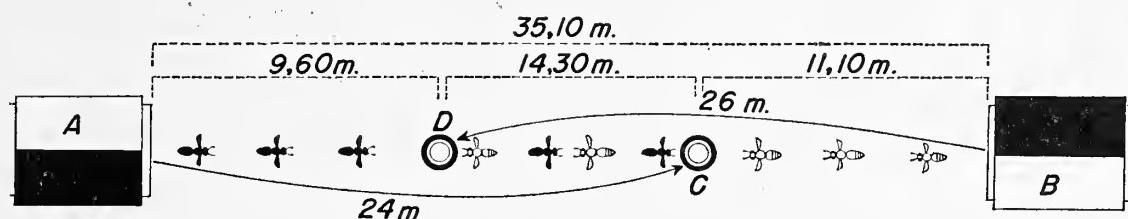


Fig. 1. Experiment showing scent-path of *Trigona postica* having a gradient of strength among the scent marks. Bees from A trained to feeder C accumulated on this feeder, in spite of feeder D on the scent path as well as bees marked from D to B.

her hive. One bee of B was trained to feed at the food source D, 26m from the hive, also on the line connecting A and B. While the food source is being moved, the bee usually does not mark; the concentration of the syrup was 45%. It required about one month of several trail places, repeated several times, with several pairs of hives, until we were able to obtain the marking of both bees, at the same time. This occurred on the 22nd trial when the yellow bee from A marked the ground at 4.37 P.M. and the white one from B marked at 4.40 P.M. Both bees marked again exactly at 5.00 P.M. Ten minutes after the first marking, the newcomers began to arrive at the feeding tables and were marked soon after they alighted, with the same color as the scout bee, that is, bees arrived to tables C were marked yellow and bees to table D white. Ten minutes after the marking of newcomers, some already marked began to arrive at the wrong place that is,

either the arrival of yellow bees to D or white bees to C. After 5.00 P.M. many bees again made scent-marking, both from C to A and D to B. At 6.00 P.M. the experiment was completed. Following are the results:

On feeder C, a total of 74 yellow bees and 4 white (94.7% correct) ;

On feeder D, a total of 142 white bees and 8 yellow (90.4% correct) ;

To hive A, 35 yellow bees and 5 white entered during one minute (87.5% correct) ;

To hive B, 76 white bees and 12 yellow entered during one minute (86.3% correct).

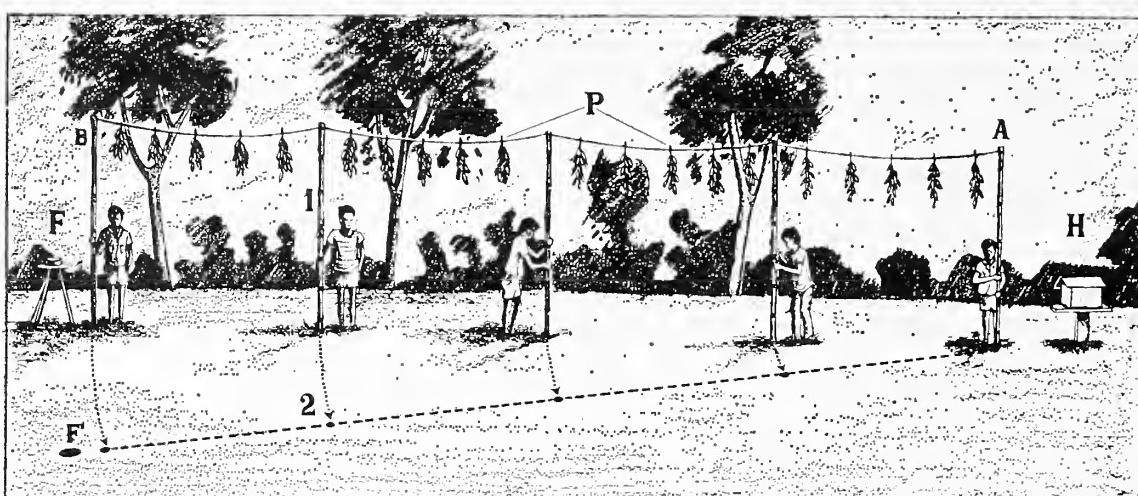


Fig. 2. Wire held by bamboo to detect duration of scent mark made by *Trigona bipunctata*. When the scout bee began marking, poles were moved to dotted line.

If bees lacked a gradient of scent to follow, that bees from hive A could be expected to accumulate on table D and those from B on C. This did not happen, for the results deviate significantly even from the probability of 0.50. Therefore, we can safely conclude that the marking bees make a scent path of which strength is not equal in all marks but attracts the bees with a predetermined gradient which newcomers follow, distinguishing marks that are stronger or weaker than those they are instinctively conditioned to follow. Indications of this gradient in the scent path was then sought.

A bee of *Trigona (Scaptotrigona) postica* was trained to collect food at a place 50m far from her hive. A wire of 60m

long supported by 5 bamboos (Fig. 2) 3m high, connected the point A, 4m from the hive (H) to the other B, right after the feeder (F). Several small branches of coffee trees were fastened on the wire, 1.5m apart from one another. The time spent by each marking bee to make each scent-mark in the line, was recorded separately for the first 12.5m and for the second 12.5m (from feeder to hive). The following results were obtained:

1st section: average 2.1" per mark ($S = 1.04$).

2nd section: 5.0" per mark ($S = 2.9$).

For 3rd and 4th sections no reliable data was obtained. One thing was evident, however: the means and the standard deviation of the duration of marking increased ($P < 0.05$) with the increased distance from feeding place. We may advance a hypothesis that the mandibular glands release so much scent secretion for the first markings than the subsequent ones that a longer period is necessary to release even lesser amount of perfume.

8. How long does the effect of the perfume released by scent marking bees last?

Three species were used: *Trigona (Scaptotrigona) postica* and *T. (S.) bipunctata* whose workers mark with average distance between two marks around 2m or less, and *Trigona (Trigona) spinipes* which has an average distance between marks greater than 7m. The experiments and the results follow:

A bee was trained to collect syrup at 30m from the hive in *T. postica* and 50m in *T. bipunctata*. A wire held by four and five bamboos was stretched from the hive to the feeder. Each bamboo was 2.50m and 3.0 high and held by a boy. Each wire, at intervals of 1.2–1.5m, bore branches (a meter long) of Eucalyptus or coffee-tree for *T. postica* and *T. bipunctata* respectively. When the trained bee finished the marking the boys moved the bamboo from position 1 to position 2 (Fig. 2). A new feeder was put in the old place and was immediately visited by the trained bee. After these markings the newcomers began to arrive to the feeder F'. After some minutes bees ceased to arrive. Every new bee was imprisoned soon after arrival. The period was recorded from first marking to the arrival of the last bee and was 13' in *T. (S.) postica*. It is interesting to note that this period is similar to that obtained by Lindauer and Kerr

(1960) which was 15'. However, the branches used by the latter were wet and more than one bee had marked on them systematically. In *T. (S.) bipunctata* (which is close to *T. postica*) the arrival of newcomers to the new position lasted 14'.

In a second experiment done with *Trigona (S.) bipunctata*, we waited for a large number of bees to arrive and marked an enormous number of them. Newcomers arrived in the new spot for more than 19 minutes. In all cases the search was intense for 8 minutes, decreased steadily thereafter.

In *T. (T.) spinipes* the bamboos held the wire 20 to 46m from the hive, and the branches on the wire were spaced 1.20m apart. In the experiment, repeated thrice, the period of the scent was 8', 9', 11' respectively. In the first two experiments the weather was warm and windy but in the last one was slightly rainy.

Therefore, we can conclude that the duration of the marking scent in *T. (S.) postica* and *T. (T.) bipunctata* averages 15 minutes and in *T. (T.) spinipes* 9 minutes. It is worthwhile to note that the scent-glands of *T. (S.) postica* are well evolved (Nedel 1959, Cruz 1960) while of *T. (T.) spinipes* it is more primitive (Cruz 1962).

9. How old must a bee be to scent-mark or follow a scent-path?

A group of *T. (S.) xanthotricha* Moure were raised from a hive of *T. (S.) postica*. When these workers were 42 days old, they began foraging. From that point on, every day a group of *postica* was trained to obtain food 20m from the hive. Every day a group of *postica* was attracted by scent marking bees. Only when the *xanthotricha* bees were 51 days old were they able to follow a scent-path. When they were 55 days old the first *xanthotricha* made its own scent-marking operation. Therefore, we conclude that communication, being a more complex operation, is executed by a bee only after about 15 days of foraging, even though she was able to follow a scent-path made by other scout bees from the 10th day of foraging. Hebling, Kerr and Kerr (1962) studying labor division in *T. (S.) xanthotricha* found that the average span of life of these bees is 94 days.

10. Do bees of a species follow a scent-path made by a bee of other species?

Lindauer and Kerr (1960) described an experiment through which it was demonstrated that bees of one hive of *T. (S.) postica*

were able to follow the smell track of other hives of the same species with the results shown in Fig. 3. After the above (9) experiment we determined to seek a more generalized answer.

A hive A of *T. postica* was trained to feeder C and hive B of *T. xanthotricha* to feeder D. The scent-mark crossed 7m from both hives. The results were : 120 *postica* were attracted to *postica* feeder C, and 2 to *xanthotricha* feeder D ; 96 *xanthotricha* were attracted to *xanthotricha* feeder D and 28 to *postica* feeder C. We can therefore say that *xanthotricha* follows easily the scent-path left by *postica* but *postica* has lost almost all her ability to

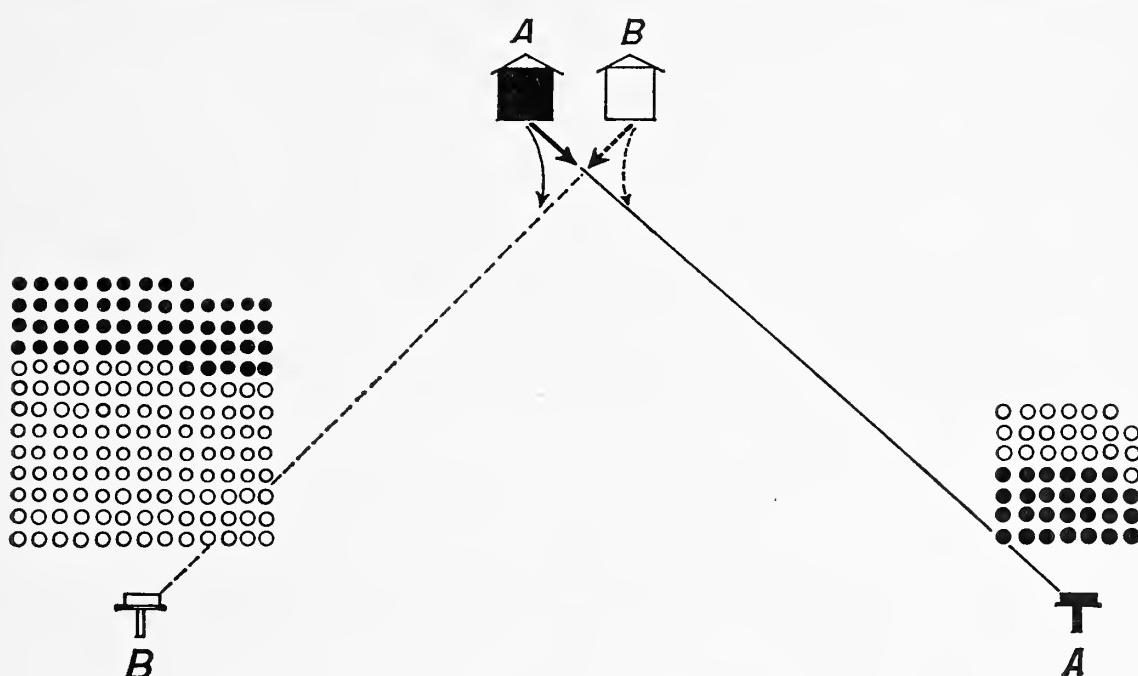


Fig. 3. Experiment by Lindauer and Kerr (1958) showing bees from hive A trained to feeder A and from hive B trained to feeder B, if scent-marked simultaneously, can attract bees from other hive. This showed that scent is characteristic of species and not of a colony.

follow *xanthotricha* scent. This suggests that *xanthotricha* is a more recent species, that has developed a new type of smell (not received by *postica*) but still has nerve cells capable of detecting the scent of *postica*.

Similar experiments done with *postica* and *spinipes* lacked positive results. These species are unable to follow scent-paths of one another.

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THE ANATOMY OF THE ADULT QUEEN AND
WORKERS OF THE ARMY ANTS *ECITON*
BURCHELLI WESTWOOD AND *ECITON*
HAMATUM FABRICUS

Roy M. WHELDEN

[CONTINUED]

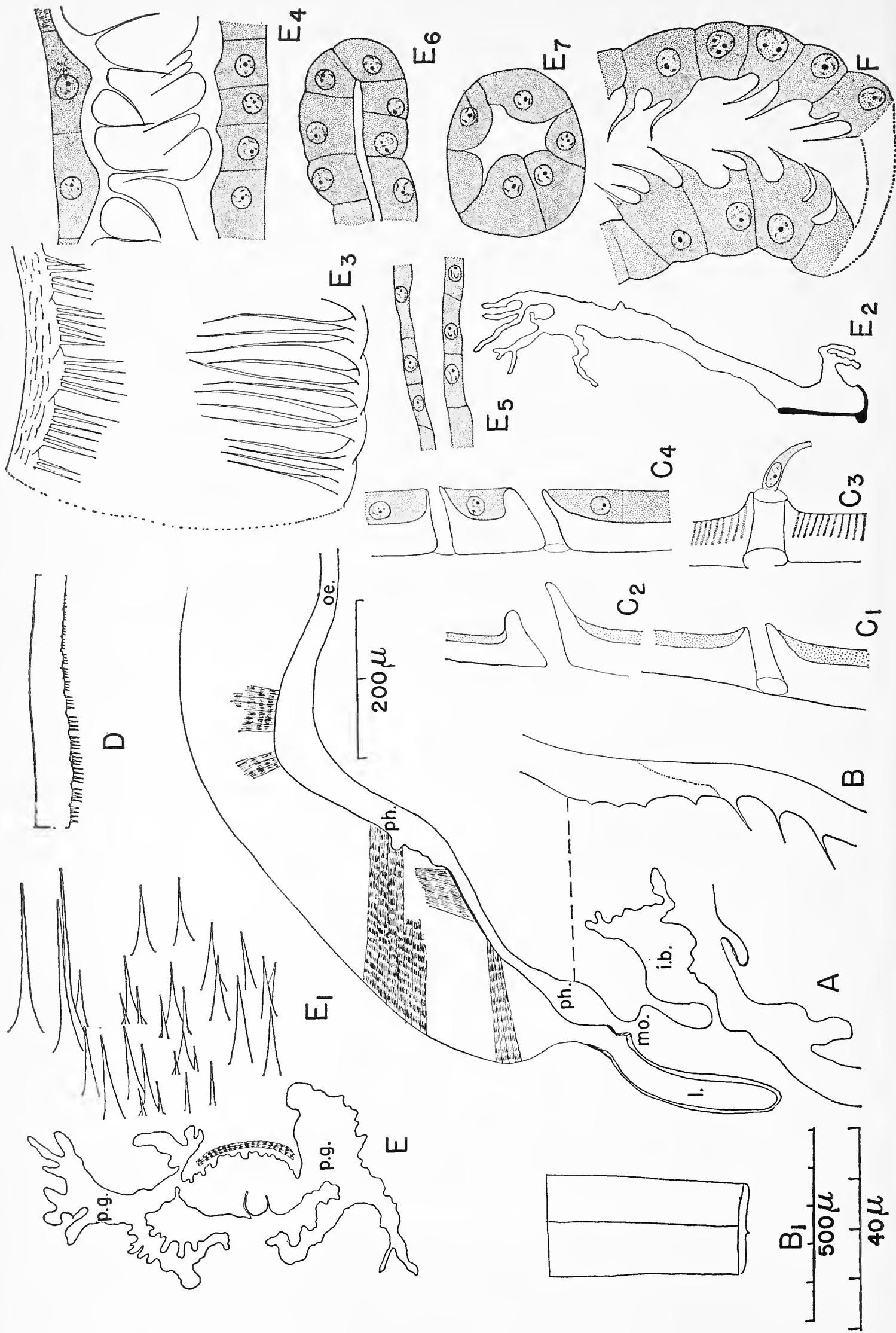
Basically the pharynx of these two ants is a large, flexuous tube more or less parallel to the frontal surface of the head. Its walls give the impression of variability of structure since even the smallest variation in the angle or in the region of sectioning can produce a striking difference in appearance. Despite the appearance of rigidity of the thick, darkly pigmented wall, this wall is probably flexible and elastic, which may also cause changes in appearance. What follows is to be considered only as a description of its appearance, subject to variation in dimensions and outline.

The lowest portion of the dorsal wall is similar to the wall of the buccal tube which it adjoins, but the spines from its inner surface are much finer. These spines occur for a short distance

only, usually gradually decreasing in size until replaced by low transverse ridges which are present in gradually decreasing size until they cease (Fig. 4, A, B), before the midpoint in the pharynx. Often there is a long portion that is smooth. Beyond this mid-point, fine spines appear in transverse rows (Fig. 4, D). These spines vary in length, though always short, as far as to where the pharynx bends strongly backward; from this point on to the beginning of the oesophagus, the spines on the upper surface are much longer and less obviously in rows (Fig. 4, E₃). Throughout its length this dorsal wall of the pharynx is strongly pigmented.

A series of transverse sections of the pharynx of a queen of *E. burchelli* (Fig. 5) shows the difference possible upon sectioning at different levels or at an angle. Where the diverticulum of the maxillary gland occurs, a transverse section shows the dorsal wall uniformly thin, contrasting sharply with the thicker more heavily pigmented ventral wall (Fig. 5, A). In the region above the maxillary gland, both the dorsal and the ventral wall of the pharynx also show changes. The dorsal wall is strongly arched upward in the middle area and very thick, gradually narrowing towards its lateral margins, where it turns suddenly outwards and abruptly becomes thin (Fig. 5, B). From the central arched area, a broad muscle mass extends to the dorsal wall of the anterior head region. Two large muscle masses occur, one on each side of the central mass; which more or less parallel the pharynx. The ventral wall of this part of the pharynx ends laterally in large cylindrical masses, deeply pigmented. In more posterior sections a gradual thinning of the dorsal wall is seen with an accompanying narrowing of the central muscle mass. Where the thickening of the dorsal wall ends, a new muscle mass occurs (Fig. 5, C). This is attached to the central (thickest) part of the wall and passes upwards, dividing the muscle first mentioned above into two narrow parts. This central muscle gradually increases in size as it passes upwards to its central attachment to the mid-frontal wall. The two large lateral muscles accompany the central one. The thickness of the dorsal wall continues uniform for the rest of the length (Fig. 5, D to H, inclusive).

The ventral wall gradually changes in the lateral margins of the thickened region, the cylindrical form becoming rapidly



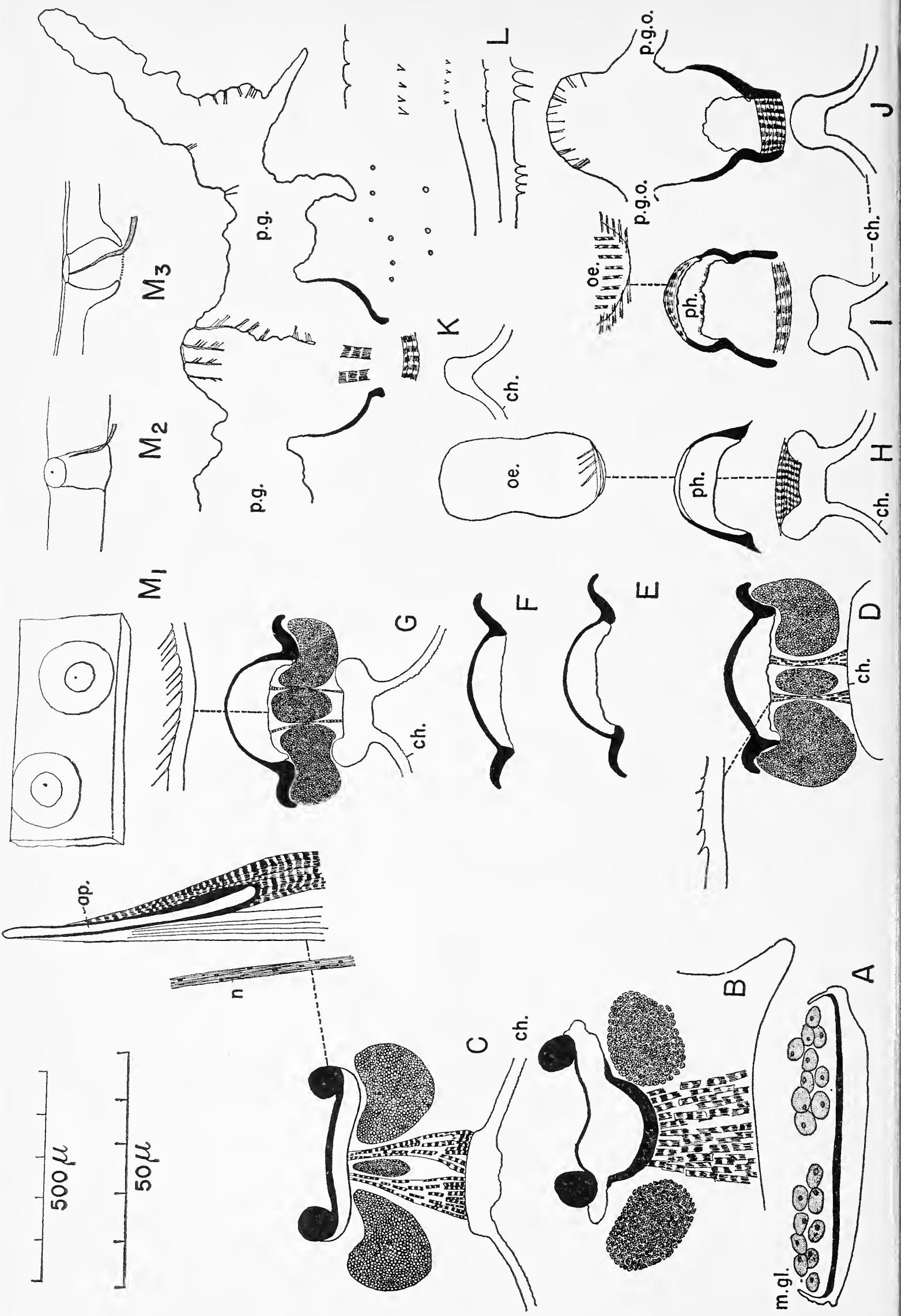
smaller, with upcurved narrowing flanges to nearly the posterior end of the pharynx (Fig. 5, D through H), where they gradually fade as part of the wall of the post-pharyngeal gland chamber (Fig. 5, I, J).

The inner surface of the ventral wall of the pharynx has a short area thickly armed with coarse forward-directed spines which gradually decrease in size near their upper limit. After this the ventral wall is smooth for most of its length and is characterized by the occurrence of about twenty large pits, in four irregular rows of five each. In the queens, each of these pits is about $8\ \mu$ in diameter and nearly cylindrical; often the wall projects outward around the base of the pit, forming a projecting ring (Fig. 4, C₁₋₄; Fig. 5, M₁₋₃). A thin membrane closes the inner end of the pit; in or near the center of this membrane, a minute conical papilla occurs. In workers, the wall of this part of the pharynx rarely exceeds 5–6 μ in thickness. Here the pit projects from the pharynx wall forming a stout collar nearly 10 μ high. The wall of the collar is 2–3 μ thick.

Into each of these pits, a slender nerve fibre enters and passes

FIG. 4. The pharynx and pharyngeal gland.

- A Semidiagrammatic pharynx and associated parts:
l = labrum; mo = mouth; i.b. = infrabuccal pocket;
ph = pharynx; oe = oesophagus
 - B Ventral wall of pharynx, near mouth. Dotted line: junction of pigmented wall (above) and colorless wall (below)
 - B₁ Dorsal wall, showing relative thickness of two layers
 - C₁₋₄ Ventral wall, showing large pits in posterior half of wall in queen
 - D Dorsal wall of pharynx, near junction with oesophagus
 - E t.s. anterior oesophagus, with lateral chambers of post-pharyngeal gland (p.g.) in queen
 - E₁ Inner surface of wall of these chambers, showing long spines
 - E₂ Chamber of pharyngeal gland
 - E₃ Wall of main branch of chamber of pharyngeal gland, near oesophagus, showing transverse rows of long spines
 - E₄ Branch of pharyngeal gland, transitional between chamber and secretory portion
 - E₅ l.s. of pharyngeal gland of worker, near base of branch
 - E₆ l.s. end of branch of queen pharyngeal gland
 - E₇ t.s. of queen pharyngeal gland, near end of branch
 - F l.s., secretory branch of the male pharyngeal gland
- Scale: E and E₇—500 μ scale; others—40 μ scale



upwards, occasionally free in the central region, frequently near or against the lateral wall, and ends just beneath the small conical papilla (Fig. 5, M₂, M₃).

Relatively small muscles pass from the ventral wall of the pharynx to the inner surface of the upper end of the large tentorium projecting upwards from the ventral wall of the head (Fig. 5, C, ap). Another slender muscle extends posteriorly from the wall of the pharynx through the brain parallel to but below the oesophagus and to end in the posterior wall of the head. This muscle varies considerably, especially in the queens. It may be formed of eight separate heads inserted into a single slender tendon or frequently fewer heads with a single muscle mass at the point of its origin near the neck opening.

The transition from pharynx to oesophagus is not sharp, and occurs at some distance posterior to the prominent bend in the pharynx. The oesophagus varies between the various forms and in various regions in a single individual. Characteristically, it is a straight tubular organ, the inner surface of which is abundantly armed with long, acute spines, usually directed forward (Fig. 3, C₂). These spines, conspicuous in queens, measure from 20 μ to 35 μ in length. Yet occasional individuals lack spines on the inner surface of the oesophagus or have spines in limited regions. Smoothness of the oesophagus wall is commoner in soldiers than in other forms. Individuals occur with the oesophagus free from spines only in the thorax, or in the anterior portion of the

FIG. 5. Pharynx of *E. burchelli* queen (series of transverse sections about equal intervals): pigmented portion of wall shown in solid black. Figures oriented with dorsal wall below.

- A Just above mouth, beyond area of bristles surrounding mouth cavity, maxillary gland (m.gl.)
 - B-G Changes in extent of pigmented portion of wall, details of dorsal wall in D and G (in C, nearby nerve (n) apodeme (ap) and muscles, body wall (ch.)
 - H Anterior end of oesophagus (oe), upper end of pharynx (ph)
 - I Junction of pharynx with oesophagus
 - J Apex of pharynx with edge of openings of pharyngeal gland (p.g.o.)
 - K Extent of chamber of pharyngeal glands (p.g.)
 - L Dorsal wall of I
 - M Several pits in posterior part of ventral wall
- Scale: L₁, M₁, M₂, M₃, D and G = 50 μ scale; others = 500 μ scale

thorax, or only in that part of the oesophagus which is overlapped by the brain. When present, the spines frequently occur singly; less frequently in transverse rows of four to six spines. Often these rows of spines occur only on the dorsal wall, the opposite wall being smooth. When spines occur over the entire surface, those on the ventral surface may be $35\ \mu$ long, while on the dorsal surface they measure less than $12\ \mu$.

Surrounding the oesophagus from one end to the other, is a loose network of muscle fibres that may be vaguely separated into two layers. In these the fibres are so irregularly arranged that longitudinal and circular layers are difficult to distinguish. (Fig. 3, C₁₋₃).

A large irregular opening through the lateral wall of the oesophagus, posterior to the transition from pharynx to oesophagus, leads into the chamber of the post-pharyngeal gland. Structurally it is the same in the queen and all worker forms; yet its form seems to be different. In the queens, the gland is large, by far the largest object in the head; its many branches extend over the brain and even back of it, fill much of the space between the brain and the lateral walls of the head, and form a dense mass anterior to the brain. So large is it that the mandibular muscles, the largest found in the head, are reduced to thin plates against the lateral wall. In workers, this gland is much smaller, with relatively few branches, most of which occur anterior to the brain. In soldiers, this gland is formed of a few well-separated slender branches, some above and some lateral to the brain, but not near it, and some shorter anterior branches.

These branches arise from the walls of a large chamber, which in the queens is irregular in shape, and with several coarse irregular branches (Fig. 4, E₂; Fig. 5, K). The chamber walls are thick, uneven, and bear internally many rows of long acute spines, measuring 30–45 μ in length. These spines usually occur in rows of four to six, those in each row about equal in length (Fig. 4, E₃).

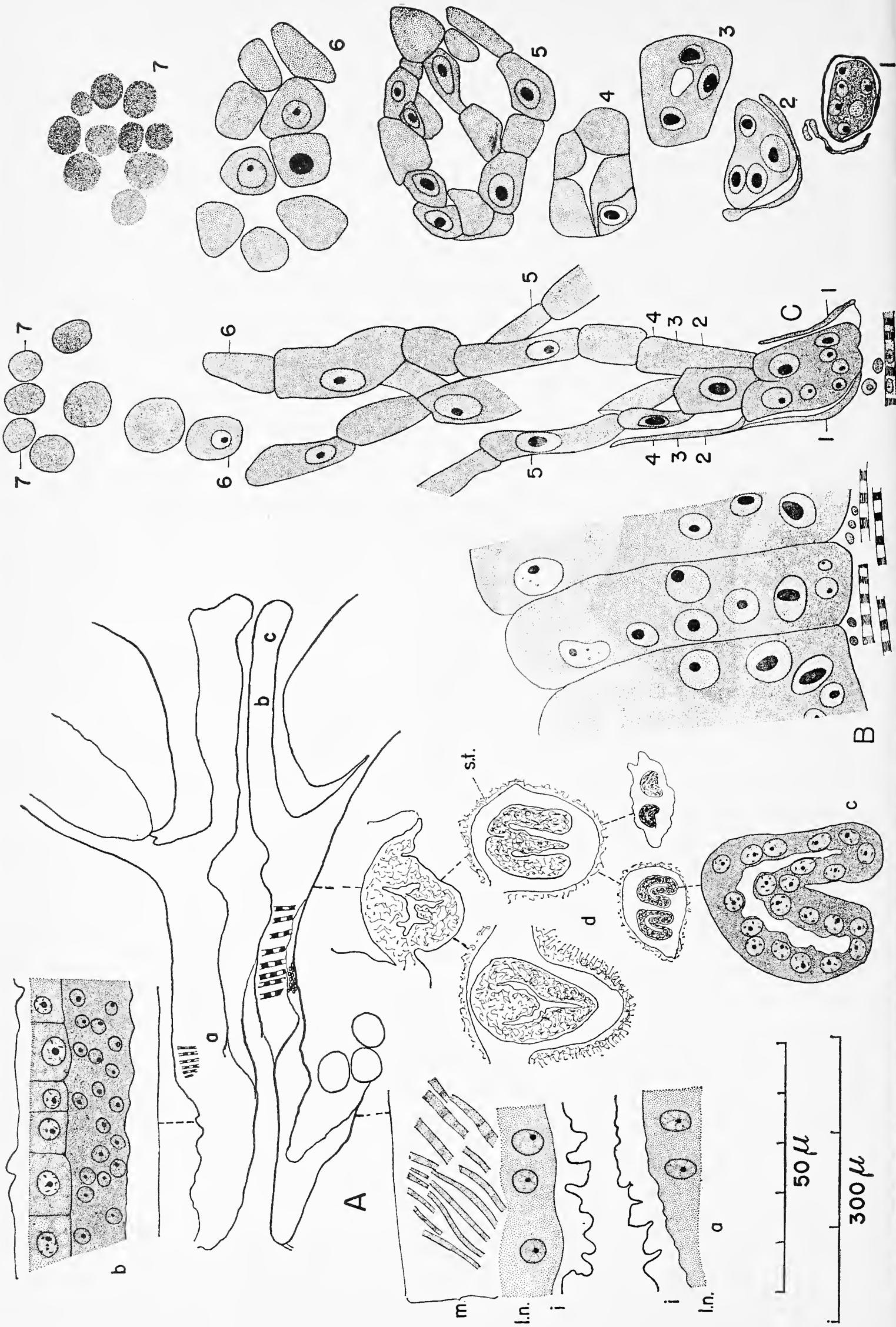
The secretory branches arising from the walls of the main chamber and from its several coarse, often long branches are uniform in size and appearance. In the queens, the average diameter is 15–18 μ , with the central lumen 2–3 μ in diameter (Fig. 4, E₄₋₇). In all workers, these branches are usually larger than those in the queens, having a diameter of 18–24 μ , with that

of the central lumen $5\text{--}6 \mu$; infrequently, this central lumen may be as much as 12μ in diameter, especially near the base of the branch. In males, the branches of this gland are generally smaller, averaging about 12μ in diameter, with a lumen $3\text{--}4 \mu$ in diameter. Frequently, the lumen is larger, with many large curved spines projecting into it. These spines are thin-walled, with cytoplasm reaching far into the center of the spine. The small spherical nuclei occurring in the secretory branches measure $3\text{--}4 \mu$ in diameter (Fig. 4, E₄, F).

The small crop of the queens is found in the anterior part of the first gastric segment; in the workers, it occurs near the mid-portion of the first segment. In either form, the wall of the crop is thin and has a few small discoid nuclei. Muscle fibres are either completely absent from the wall of the crop or occur sparingly.

The proventriculus, like the crop, is small, more so in the queens than in the workers. Its structure is identical in all forms. The anterior and posterior parts are separated by the junction of the proventriculus to the anterior end of the wall of the stomach (Fig. 6, A). The anterior part is larger, especially in the workers. In the workers, the longitudinal axis of the two parts forms a straight line; in the queens, this occasionally occurs, but often the anterior part forms a sharp angle (about 80°) with the posterior part. This may be a result of the rhythmic change from contraction to physogastry.

The anterior part of the proventriculus varies in length from 400 to 550μ , with a maximum diameter from 120 to 180μ . As a rule the greater lengths occur with the smaller diameters, perhaps an indication of variation in shape as well as in position during physogastry. Four distinct layers of tissues form this anterior part. The innermost is a colorless featureless wall from 3 to 8μ in thickness; the inner surface of this layer is much wrinkled (Fig. 6, A-a). External to this inner layer, is a unicellular layer 6 to 14μ thick. This layer may be compared with the hypodermal layer of the external wall. Surrounding this is a much thicker layer of muscle fibres sometimes circular, but often almost radial, due to the irregularity of the wall and consequent variation in the angle of cutting. External to this is the fourth layer, much thinner than any of the other three and composed of longitudinal muscle fibres. Finally, there is a thin featureless wall external to these longitudinal fibres.



Transverse sections of this anterior part of the proventriculus show clearly the four layers described above and also show the muscle fibre variability of the third layer. Also shown is the variable nature of the central lumen. Sometimes this central lumen is large and almost cylindrical, the enveloping wall being uniformly thin. Or the wall is so collapsed that the central lumen is almost obliterated, there remaining only a small central portion from which three or four irregular, unequal narrow arms radiate. In a single insect, the lumen varies from one level to another, measuring as much as $24\ \mu$ in maximum dimensions at one level and less than $8\ \mu$ at a level only slightly distant from the first.

At the point of contact with the wall of the stomach, the stomach becomes thin, with irregular small cells comprising it; similarly the cells of this part of the proventriculus become small and more or less uniform in structure.

The posterior proventriculus, within the anterior end of the stomach, is more or less surrounded by the thick walls of the stomach, but is never in contact with them. This part is smaller than the anterior part, measuring 250–270 μ in length (rarely more) and 80–120 μ in maximum diameter. The cells are more uniform than those in the anterior portion, with muscle fibres mostly lacking except in the basal region. Transverse sections (Fig. 6, A–d) show the great change from one point to another of this posterior region. Particularly noticeable is the change in the outline of the central lumen, which invariably shows many narrow radiating arms. For more than half its length, this posterior part tends to be more or less cylindrical, though

FIG. 6. Proventriculus and ventriculus.

- A Outline of proventriculus
 - a. l.s. of mid-portion of wall of main body, showing irregular muscle layer, (m) surrounding layer with large nuclei (l.n.) surrounding thick intima (i)
 - b. l.s. of wall, proventriculus valve
 - c. t.s. near tip of proventriculus, one half only
 - d. Sections of valve of proventriculus and inner margin of stomach (st.)
 - B Cells and muscle layer of stomach wall of worker
 - C Cells and muscle layer of queen stomach wall with t.s. numbered to show approximate location in wall
- Scale: A,a,b,c,B and C = $50\ \mu$ scale; A_d = $300\ \mu$ scale

occasionally somewhat compressed laterally. At some point near or posterior to its mid-point, the transverse section becomes vaguely like an inverted letter W in shape; then separated and the resulting transverse section resembles two irregular inverted U's which gradually decrease in size (Fig. 6, A-c, d).

The cells forming this part of the proventriculus are in two distinct layers, with a thin featureless inner membrane surrounding the central lumen (Fig. 6, A-b). The inner layer is formed of uniform prismoidal cells, similar to the hypodermal cells. Around this, there is a thicker layer of small irregular cells, the separating membranes of which may rarely be discerned. In this layer, thick near the anterior proventriculus, the number of nuclei gradually decreases, as does the thickness of the layer, which finally ends near the posterior end, leaving a small lumen.

In both its shape and the structure of its component cells, the stomach of the queen differs strikingly from that of the workers. In the queens, it is a more or less cylindrical body, 400–570 μ in diameter. In many individuals, the diameter is uniform from one end to the other; in others, the diameter varies greatly at different points. The anterior end is uniformly hemispherical; the posterior end varies, being short and conical in some individuals, in others drawn out into a gradually narrowing neck which may be as much as 400 μ long. This narrow portion may be in line with the main part of the stomach, or it may turn abruptly downward, in extreme examples at right angles to the main part of the stomach. The total length of the stomach, from the junction with the proventriculus to the beginning of the intestine, where the Malpighian tubules are found, varies from 2400 to 5000 μ . Variability in length is not correlated with the degree of physogastry; for of two individuals having stomachs almost equally short, one may be contracted and the other fully physogastric; two individuals with very long stomachs may also be one contracted and one physogastric. The stomach is not elastic in length.

In the workers, the stomach is always pear-shaped, and varies little in size in any single caste, but considerably from minor workers to the large soldiers. In the workers, the stomach wall is seldom more than 110 μ thick, always much less than the thinnest wall found in the queens.

In the workers, the cells of the stomach wall resemble those

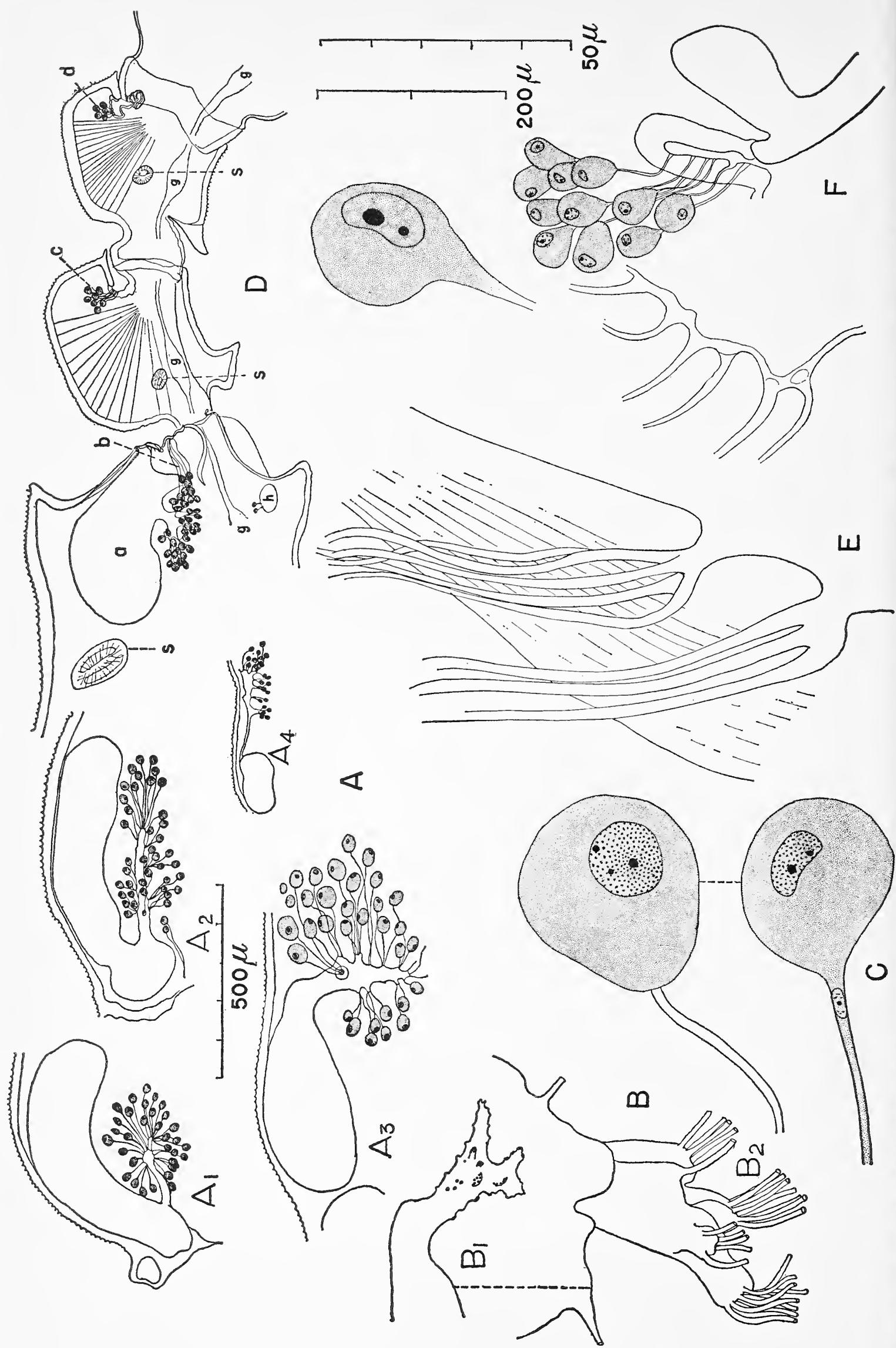
found in other ant species, being columnar and closely aggregated. In them, small nuclei occur at the base; above, larger nuclei occur haphazardly (Fig. 6, B). The cytoplasm becomes thinner and more vacuolate from base to apex in these cells.

In queens, the structure of the wall of the stomach is different. In it, the cells do not form a uniformly compact layer. Instead, each cell is separated from its neighbors not only by narrow spaces, but by thin scale-like cells that completely or partially surround the basal unit and extend to the height of the basal unit which is a multinucleate columnar cell with distinct cell membranes (Fig. 6, C). Minute discoid nuclei occur sparingly in these scales. From the apex of the basal unit, secondary scales occasionally reach upwards but do not surround the secondary units of the stomach wall. Beginning with these secondary units, the wall breaks up into coarse filaments which at first surround a central open space of irregular shape. Progressing upwards, these filaments branch several times, forming irregular, usually two to three times compound, funnel-shaped tubes. Only near the inner surface of the wall do the filaments become separated, appearing in transverse sections as groups of irregular cells 10–14 μ in maximum dimension. Above these, are numerous small spherical bodies in the central lumen of the stomach which at first have a distinct external wall or membrane, but presently have a limited outer surface. Occasionally these spheres are found in abundance in the posterior end of the stomach lumen, absent in the extreme anterior end, but increasing in numbers near the posterior end. Such a wall structure effectively increases the functional cell surface of the stomach wall.

Externally there are usually two muscle layers, the inner one of fibres encircling the stomach, the outer of longitudinal fibres.

The remaining parts of the digestive system, the intestine and the rectum, appear elastic in the queens, elongating noticeably as physogastry increases and decreasing during contraction. In the intestine, the surrounding muscle layer becomes thin at the peak of physogastry.

Occurring at the anterior end of the intestine, the Malpighian tubules (Sixteen in workers and about thirty in queens), vary from 23 to 25 μ in minor workers, 25 to 27 μ in medium workers, 32 to 35 μ in large workers and soldiers. In the queens, greater variation occurs, the extremes being 36 to 60 μ . All measure-



ments here are for the diameter a short distance above the base of the tubule; this diameter gradually decreases from base to apex. The central lumen varies even more; for example, in each of two queens both having a tubule with a diameter of about 60 μ , the diameter of the lumen in one is 20 μ , in the other 38 μ .

Contrasting sharply with the thick wall of the intestine, the rectum wall is very thin and shows conspicuous rectal papillae. In workers, there are usually three, rarely six; in the queens, frequently six, infrequently three. Viewed from the surface, these papillae are broadly elliptical, at times nearly circular; from the side, most of them have the upper surface parallel to the wall of the rectum; a small number have sloping sides that give them a conoidal outline. Their dimensions vary considerably, both between the several forms and between individuals of any single form; average dimensions are: minor workers, 170 by 120 μ ; medium workers, 220 by 140 μ ; major workers, 320 by 185 μ ; and queens, 440 by 185 μ . In about one-sixth of the length

FIG. 7. Glands of posterior thorax and petiole.

- A Variations of metasternal gland, showing chamber, secretory cells, ducts and diverticulum into which ducts open
(*E. hamatum*)
 - A₁ Metasternal gland of medium worker, with diverticulum opening near base.
 - A₂ Medium worker, with diverticulum opening near base. Two cells of nearby small (intermediate) gland, below chamber base
 - A₃ Large worker, with diverticulum from apex of chamber
 - A₄ Minor worker, with diverticulum from apex of chamber
 - B₁ Apex of diverticulum with duct openings
 - B₂ Duct openings with bases of ducts
 - C Secretory cells of metasternal gland, with nucleus on duct near secretory cell
 - D Posterior thorax, petiole and post-petiole, also anterior part of gaster (parts in sequence here, but not from single ant), metasternal gland (a), intermediate gland (b), gland in petiole (c) and in post-petiole (d)
 - E Openings of ducts of intermediate gland in posterior thorax, through membrane connecting thorax to petiole
 - F Gland at leg base, with ducts opening through membrane joining coxa to thorax, secretory cell (above) and duct openings (at left) of gland
- Scale: A and D = 500 μ scale; B₁ and F (whole gland) = 200 μ scale; B₂, C, E, F (details) = 50 μ scale

of the posterior rectum and around the anus, the wall becomes thick, the greater part being circular muscles.

Within the rectum, and to a less degree in the intestine, several large irregular masses of fecal matter may be observed. These are colorless, but contain many small particles of solid matter, some of which may be the remanis of the small spheres cast off from the apical portions of the stomach wall.

GLANDS OF THE THORAX AND GASTER

Smallest of the thoracic glands are six glands in the ventral region, one at the base of each leg (Fig. 7, F). Each of these glands is just above the base of the leg, lateral and often slightly posterior to this base. The glands are small, composed of 5–6 cells in the minor workers, and 12–15 cells in the queens, the cells usually compacted in dense masses, but occasionally found loosely grouped. Variation in shape includes those nearly spherical to some elongate conoidal; sample measurements in queens are 5 by 45 μ (a small, narrow cell), 58 by 44 μ (a rotund example), 70 by 36 μ and 90 by 33 μ . In workers the cells are less than half as large. The nuclei vary even more than do the cells; spherical and 24 μ in diameter or discoid and measuring 28 by 21 μ , 22 by 14 μ , or 20 by 18 μ ; to an irregular shape.

The ducts are nearly always short and irregularly curved, to provide for the movement of the legs. These ducts have uniform diameters of 1.3–2 μ ; they flare conspicuously at their mouths. Mostly, the duct openings occur singly; rarely do two to four ducts open so closely together that their common openings form a deep invagination of the membrane. Over much of the membrane, which joins the lateral wall of the thorax to the base of the outer wall of the coxa, the external surface is uniformly covered by small mamillate bosses, each topped by a slender acute small spine about 1.5 μ long.

The large chamber of the metasternal gland is often visible through the wall of the posterior thorax, especially in lightly pigmented individuals. It is possible carefully to lift off the overlying body wall, exposing the smooth, often glistening outer wall of the chamber of the gland, closely pressed against but never adnate to the body wall.

In the two *Eciton* species considered here, the metasternal gland is formed of four clearly defined parts: the large chamber,

an irregular diverticulum, usually from some point of the wall of the chamber, the numerous secretory cells, and the ducts connecting these cells with the diverticulum (Fig. 7, A₁₋₄).

The shape of the chamber is partly determined by the laterodorsal wall of the posterior thorax, against which it lies; its length is limited by the third thoracic spiracle and the trachea ending there. Rarely does the chamber extend to that point; usually it is much less, even to less than one-half that distance. Frequently the chamber is allantoid, with a uniform diameter; occasionally, it has a diameter nearly equal to the length, in which case it has a broadly ellipsoidal or nearly spherical shape. Average dimensions are: minor workers, 170 by 100 μ to 220 by 90 μ ; medium workers, 510 by 110 μ ; large workers and soldiers, 610 by 150 μ ; and queens, 750 by 200 μ .

The diverticulum into which the ducts of this gland open may arise from any point on the inner or ventral part of the wall of the chamber or from the anterior end. In extreme examples, it may originate from the wall of the posterior thorax below the chamber opening or between this opening and the junction of the thorax with the petiole. It is always coarse, of irregular shape and usually bears several short coarse branches along its sides. Occasionally, four to six nearly equal short blunt branchlets occur at the apex of the diverticulum (Fig. 7, B, B₁). The length of the diverticulum varies greatly, and may best be given by comparison with the length of the chamber; a long example may be nearly twice the length of the chamber and a short one may be less than one-sixth its length. No individual was found to have two distinct diverticula, though in two individuals branching occurred so near the base that a casual glance would lead to the conclusion that two short diverticula were present. The opening of the diverticulum, like that of the chamber, is irregular, though usually approximating a broadly oval outline. Often there is considerable asymmetry, the diverticulum and the chamber on one side of the thorax being of different shape from that on the other.

The many ducts of the metasternal gland, one from each of the secretory cells, open variously into the diverticulum; occasionally, the openings occur singly, though these openings usually form rather obvious small irregular groups; often as many as twenty ducts open so closely together they form a coarse cribellum or

even a small secondary diverticulum at any point on the main one. Rarely does a duct open directly through the wall of the chamber, usually near the base of the diverticulum. The length of the ducts is determined by the position of the secretory cells.

These secretory cells (Fig. 7, C) vary in shape and in size as much as do the cells of the several glands of the head. The most frequent shapes vary from nearly spherical, measuring 150 by 145 μ , with a spherical nucleus 12 μ in diameter to others measuring 195 by 180 μ , 190 by 150 μ , or 180 by 100 μ . Extreme variants may measure 250 μ in length and only 60–65 μ in diameter; usually such extreme cells occur near the end or at the margin of a group of cells. The cells of this gland generally form a compact group of irregular shape; their number which varies from one form to another, is fairly constant within any form. In minor workers, in which the smallest cells are usually found, the total number is 120–180; in medium workers, 200–300; in large workers and soldiers, 300–500; and in queens, in which the greatest variation occurs, there are at least 800 secretory cells. These numbers are obtained by counting the number of duct openings.

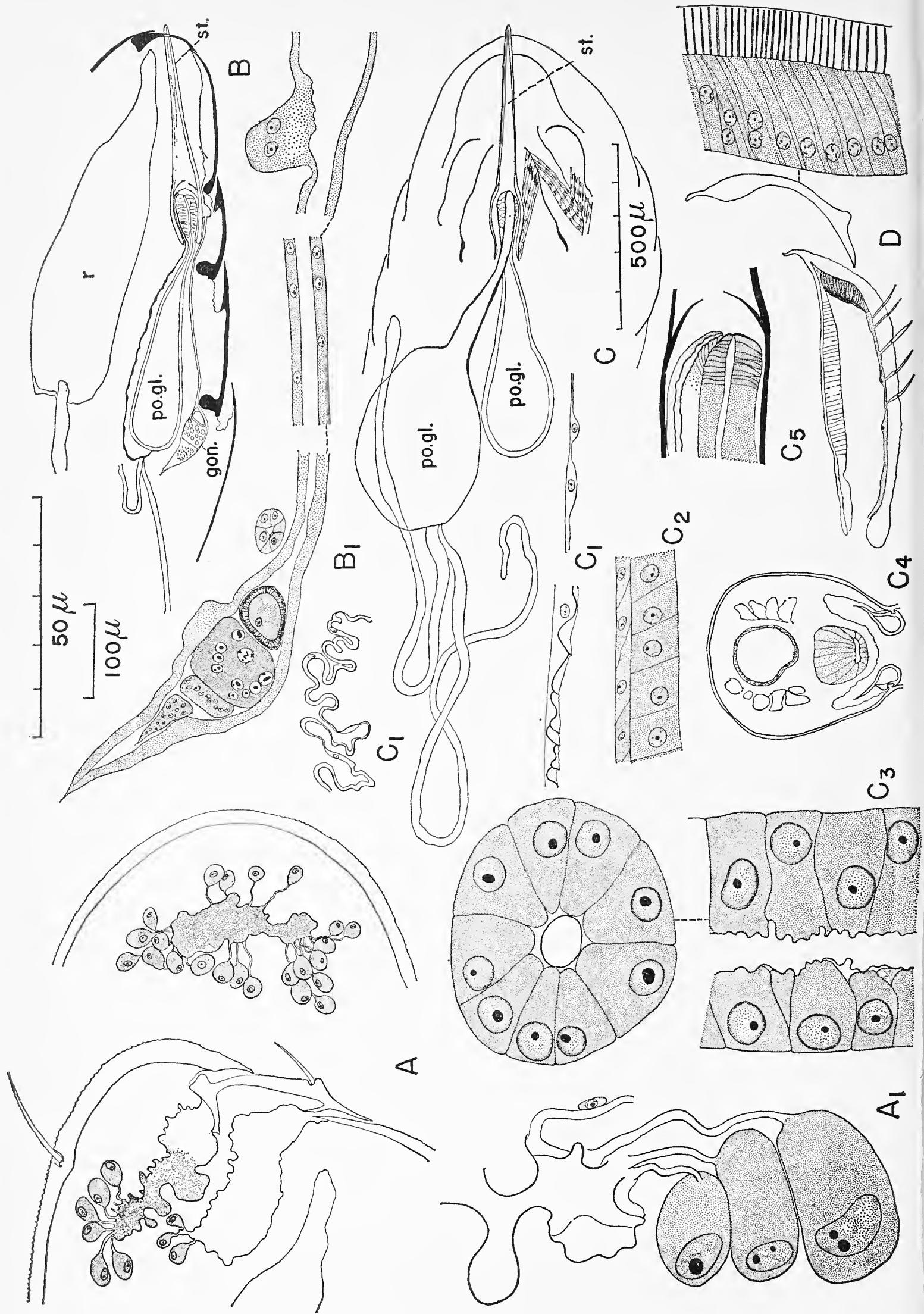
Another gland found in the thorax of the queens (Fig. 7, D, b) is a moderately large one, though small in comparison with the metasternal gland with which it is closely associated. It is scarcely possible to distinguish the cells of these two glands except by noting the opening of the ducts. In this second gland, these ducts open, usually in compact groups of three to eight (Fig. 7, E), through a membrane which connects the thorax to the petiole, near the lower part of the lateral wall. The secretory cells, numbering from thirty to fifty, or more, are mostly peripheral to the cells of the metasternal gland; although many occur within the aggregate of the metasternal gland cells, from which they may be distinguished only by the opening of the ducts.

A somewhat smaller gland occurs in the petiole of the queen; in this gland (Fig. 7, D), the openings of the ducts are always separate, and near the dorsal part of the membrane. In the workers, a much smaller gland occurs in the petiole and in the post-petiole; here the gland is much smaller, having six to twenty cells, the smaller number in minor workers, the larger in majors and soldiers.

Conspicuous among several large glands of the gaster of the queen are the paired glands analogous to those found in the petiole. Each of the segments of the gaster, including those telescoped together in the posterior part, contains a pair of these glands, which are smaller in the anterior segment than those in the following four segments. In the smaller telescoped segments, there is a progressive decrease in size. Each of these glands is found near the posterior edge of the segment and in the upper lateral region. In fully contracted queens, the secretory cells of the gland, one to several hundred in number, form a compact mass of irregular outline, 2–4 cells thick; in fully physogastric queens, these cells have been carried apart sufficiently to form a single layer of well separated, unevenly spaced cells. The cells vary in shape, some being nearly spherical, many being elongate conoidal or irregular, and a few—usually near the margin of the gland—being elongate and having a length three times their diameter. Dimensions of several cells are 60 by 33 μ , 50 by 41 μ , 40 by 34 μ , 38 by 33 μ , and 74 by 60 μ . Each of the cells narrows abruptly to a short duct 1.5–2 μ in diameter. In contracted queens, these ducts are contorted; in physogastric queens, they are nearly straight. They open separately through the intersegmental membranes.

The last pair of these glands, found near the base of the sting, in the irregular modified segment is smaller and more compact than any of the others. In this segment, deep in the posterior part of the gaster, a part of the cuticle is thick and strongly pigmented, contrasting noticeably with the thin, colorless, wrinkled membrane forming the greater part of its surface. In this segment, the ducts of this pair of glands open through the thick, pigmented wall and not through the thin membranous region.

In the workers of all forms, the gaster glands are reduced to two pairs, occurring at the extreme posterior end of the gaster (Fig. 8, A). The dorsal plate of the body wall curves down sharply, having an almost spherical surface. Below this and partially concealed by it, are two irregular plates which extend from the sides. These two parts, the large one and the smaller lateral ones, are joined by an extensive, somewhat wrinkled membrane forming a large irregular "cavity" opening ventrally. Beneath this, a second "cavity" is formed by a similar mem-



brane. Through these membranes, the short and slightly irregular ducts of the two glands open. Each arises from a small (45 by 25 μ to 35 by 15 μ) cell; the number of cells of the upper (anterior) gland rarely exceed forty; those of the second gland are less numerous. In these glands, it is often difficult to separate the cells of one side from those of the other, the gland appearing to be a uniform mass extending from one side to the other.

In these glands the ducts and much of the "cavity" into which they open seem to retain the substance secreted by the cells of the gland—a uniform mass staining faintly by haematoxylin. The poison glands also have this property of retaining the secretion.

The two poison glands of the workers are unlike those of the queen, although fundamentally their structure is similar.

In all workers, the two poison glands are conspicuous, and the contents of the vesicle of the acid gland stains black. This gland, the larger of the two, varies even in workers of equal size. In some individuals, the vesicle is nearly one-third as long as

FIG. 8. Reproductive system and glands in posterior worker gaster.

- A Left: s.s., showing two glands and "pocket" with secretion.
Right: l.s. larger gland (actually a pair) and "pocket" filled with secretion from gland cells
 - A_1 Larger gland, showing ducts and "pocket" portion
 - B Posterior of gaster, showing poison glands (po.gl.), sting (st.), reproductive system (gon.) and rectum (r)
 - B_1 Reproductive system: ovariole and oocyte (left), oviduct (center), spermatheca and vagina (right)
 - C Posterior of gaster, showing poison glands (po.gl.) and sting (st.) with body wall outline (l.s.)
 - C_1 (above): median wall, partially empty acid poison gland.
(below): left, wall of partially contracted gland, near gland base; right, wall of gland, distended and thin
 - C_2 l.s. of wall of alkaline gland
 - C_3 l.s. (below) and t.s. (above), anterior lobe of acid poison gland
 - C_4 t.s. sting, near base, showing openings of alkaline poison gland (below) and acid poison gland (above)
 - C_5 l.s. of sting base showing acid gland above, alkaline gland below
 - D Lobe of posterior gaster, ventral to genital opening, hypodermis and (right) detail of thickened hypodermis, posterior end
- Scale: B and C = 500 μ scale; A, C_4 , C_5 and D (outline) = 100 μ
scale A_1 , B_1 , C_1 , C_2 , C_3 and D (detail) = 50 μ scale

the gaster; in others, it is less than half. In many individuals, it is a sack that gradually enlarges from the narrow tubular form as it emerges from the base of the sting, and reaches its maximum diameter near the broadly rounded anterior end (Fig. 8, B). In other individuals, it remains a narrow but gradually enlarging tube for nearly half its length, then enlarges abruptly to a broadly ovoid or even to a spherical pouch having a maximum diameter equalling approximately half that of the gaster (Fig. 8, C). The walls of this vesicle are usually thin, with thickened regions around the occasional small nuclei (Fig. 8, C₁); the thickness of the thin areas is from 1 μ in fully distended vesicles to 2–4 μ in others. In some individuals, the vesicle wall is much wrinkled; possibly as a result of repeated stinging. But individuals known to have used the sting just before being fixed show no such wrinkling nor any decrease in the contents of the vesicle.

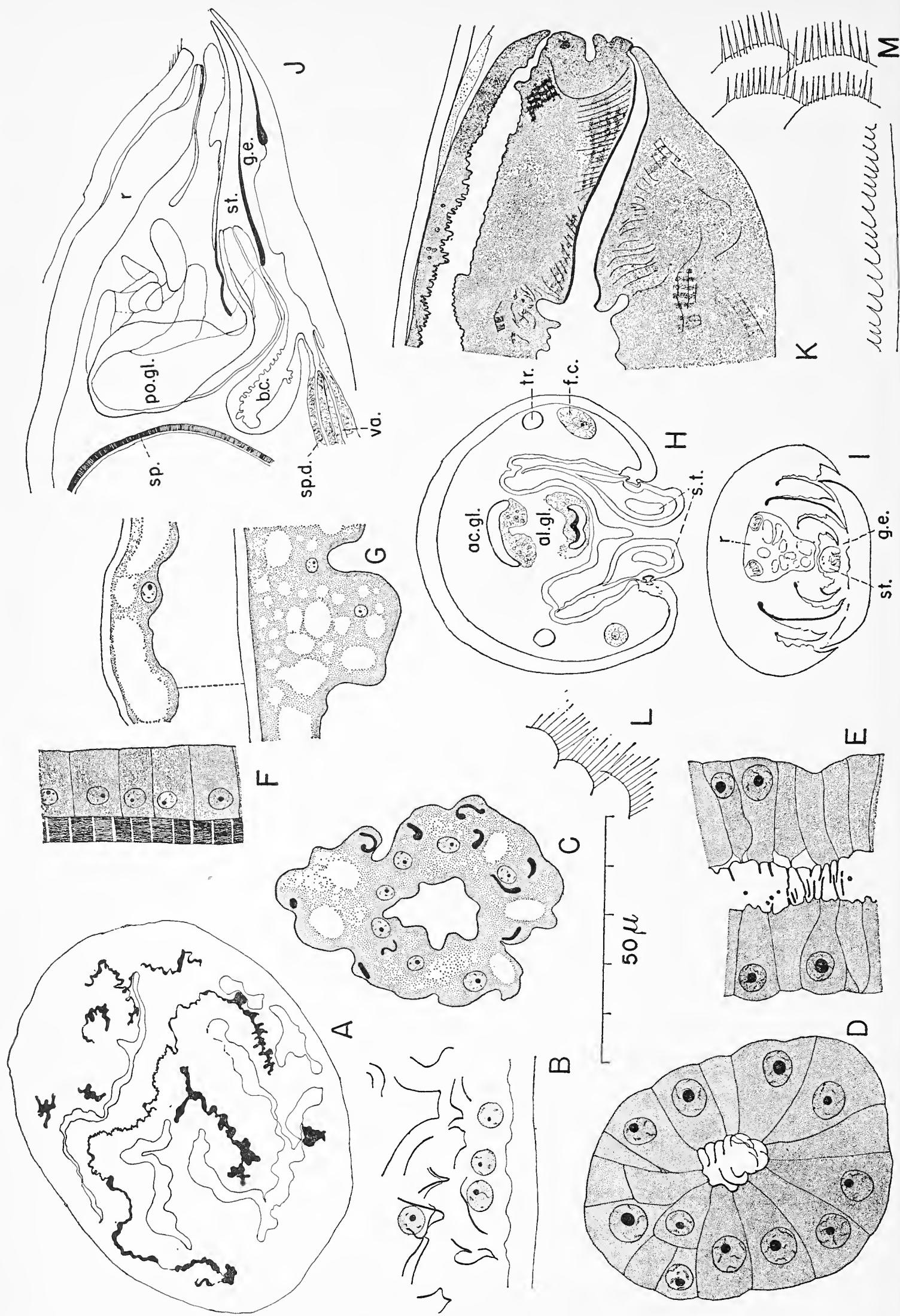
From the anterior end of the vesicle there arise two conspicuous cylindrical tubules, the secretory part of this gland. These tubules are long and often tortuous, conspicuously so in some workers. Usually both tubes extend anteriorly for some distance; then one of the tubules turns abruptly posteriorly, passing back beside or above the vesicle. The second tubule usually extends much beyond the other, even to a point near the anterior end of the gaster, before turning posteriorly. In many individuals one of the tubules forms a tangled mass of a compact nature, anterior to and above the end of the vesicle. Occasionally, both tubules form a tangled mass anterior to the vesicle. The diameter of the tubules varies according to the worker form in which it occurs, from 20 μ or even less in small workers, to as much as 60 μ in large workers. The cells of the tubules are wedge-shaped (= cuneiform in sections), with uniform cytoplasm and subspherical nuclei 6–10 μ in diameter (Fig. 8, C₃). These cells surround a lumen made conspicuous by the thick sharply defined membrane, often strongly wrinkled circumferentially. Usually the cells of the tubule are pressed tightly against this membrane; but in some workers there is a considerable space between the membrane and the inner end of the cell; in such individuals, observation shows that there will be a slender tube extending from the surface of the cell to the membrane; in such individuals, careful examination of sections tangent to the sur-

face of the membrane will usually show small circular areas which seem to be finely porous, very thin areas rather than actual pores. These are best seen in occasional specimens in which a faint stain has been retained in these areas (Fig. 9, E).

The second (alkaline) poison gland is structually unlike the first, and is much smaller. Its wall is usually formed of two layers of cells; the outer layer being of thin uninucleate cells $1.5\text{--}3 \mu$ thick, the inner of larger cells, $8\text{--}16 \mu$ thick, with spherical nuclei much larger than those in the outer layer (Fig. 8, C₂). Comparison of the alkaline poison glands of many workers shows great variation in the outer layer, which may be uniform over much of the surface, or may occur over only a portion of the surface and be irregular, or may be completely absent. This may be comparable to the muscle layer that occurs in the queens.

As the two poison glands pass into the base of the sting, they narrow to slender tubes ending anterior to the lamellae of the gorgere (Fig. 8, B, C, C₅). Invariably, the opening of the acid gland is above that of the alkaline gland; in rare cases, they may be asymmetrical, the acid gland opening being lateral to the alkaline. In nearly all cases, the acid gland opening is a flattened, transversely elongate slit which, by a turning down of the end of the gland, comes to be just over and very close to the very similar opening of the alkaline gland. The walls surrounding these openings are thick and formed of irregularly radiating tissue that even in the absence of discernible striations may be muscular. This tissue is much thicker around the alkaline gland (Fig. 8, C₄, C₅).

In queens as the two glands extend from the base of the sting, each turns upwards almost at once, at the same time separating, one going to one side, the other to the opposite side (Fig. 9, J). This is necessitated by the presence of the large spermatheca forming an effective barrier to anterior elongation, and to a lesser degree by the large bursa copulatrix. Dorsally and laterally the large rectum centrally and the several glands and muscles laterally limit the enlargement of the poison glands. Due to these limitations, the glands tend to bend backwards, becoming irregularly twisted as they approach mature size. The "anterior" lobes of the acid gland become even more compressed, sometimes lying just posterior to the wall of the spermatheca, where they may mingle with the spermathecal glands; or alongside the rectum, posterior to the vesicle of the gland.



The alkaline gland, often S-shaped, is a coarse tube of uniform diameter, with a wall of a single layer of large prismatic cells, 14–40 μ thick and outside this layer, a second layer, closely pressed against the first is a layer of distinctly striated muscle fibres, 5–8 μ thick (Fig. 9, F). The fibres are irregularly grouped but tend to be circumferential, and sometimes form two layers, one crossing the other at an angle of perhaps 30°. This muscle layer covers the entire gland, sparingly at the apex, uniformly over the entire body; and, as the opening in the sting is approached, becoming a vague, thick, irregular mass in which striated tissue is not always discernible. Where such tissue appears the component parts are variable in numbers, location, and distribution. The opening of this gland is a narrow crescent-shaped slit (Fig. 9, H).

Since space is limited, the two glands do not differ greatly in volume but the acid gland usually has greater bulk. Structurally, it is different from the alkaline gland.

The wall of the vesicle of the acid gland is simplest to describe

FIG. 9. Poison glands of queen (except D and E = part of poison gland of large worker).

- A t.s., apical part of acid gland
 - B Edge of gland, at lower level
 - C t.s. anterior lobe acid poison gland near apex
 - D t.s. and E l.s., anterior lobe acid poison gland large worker, cf. A and C
 - F l.s. wall of alkaline gland showing muscles and secretory cells (cf. Fig. 8, C₂)
 - G t.s. portion of wall of acid poison gland in callow queen
 - H t.s. base of sting—stylets (st.), fat cells (f.c.), trachea (tr.), acid (ac.gl.) and alkaline (al.gl.) glands
 - I t.s. posterior gaster, showing rectum (r), sting (st.), genital entrance (g.e.), bursa copulatrix (b.c.), vagina (va.) and spermathecal duct (sp.d.)
 - J l.s. posterior of queen gaster, rectum (r), poison gland (po. gl.), bursa copulatrix (b.c.), vagina (va.), wall of spermatheca (sp.) and spermathecal duct (sp.d.), genital entrance (g.e.), sting (st.)
 - K Posterior gaster showing openings of poison glands and ventral surface of genital entrance
 - L Spines of dorsal surface of genital entrance
 - M Spines of ventral surface of genital entrance
- Scale: H, I, and J = partly diagrammatic and less than 50 μ scale
others = 50 μ scale

as it is in newly eclosed queens. There is a dark staining (with haematoxylin stain) surface layer, uniformly 2–3 μ thick. Internal to this, is a vacuolate layer containing a few small spherical to ellipsoidal nuclei irregularly spaced. The internal margin of this layer is sharply defined in these young queens (Fig. 9, G). This layer may be uniformly 8–15 μ thick over much of the vesicle surface; but more often the entire surface except near the base of the sting (Fig. 9, lower part) is formed of an irregular layer varying from only 6–8 μ thick, to as much as 50 μ thick in a nearby area. Hence the central lumen is variable in size and irregular in shape. Queens showing this structure in the acid poison gland are rarely found. The wall of this gland is an irregular compact mass, in which almost no central lumen can be found. Both transverse and longitudinal sections show numerous irregular narrow regions many of which contain a black-staining substance. This dark substance cannot have much volume because the regions containing it are so thin. The potency of this sting gland is limited. Actually, the wall of this gland grows so much, in so restricted a space, that it becomes a thick, complexly folded mass, so completely filling the available space that in unstained material the gland appears to be an almost solid mass. The outer surface is always smooth (Fig. 9, B).

The apical tubules of the acid gland are unlike those in the workers. They are comparatively short, irregularly contorted, tapering from the large basal diameter to a narrow apex. In these tubules, the structure varies much as does the wall of the vesicle. In young queens, transverse sections show an irregular outline, both of the exterior surface and of the sharply defined central lumen (Fig. 9, C). In the wall of thin cytoplasm are many large vacuoles in the outer zone, as well as many oddly shaped "linear" masses staining black with haematoxylin, and many spheroidal nuclei 3–5 μ in maximum diameter. As the queens mature, the structure of these tubules changes noticeably and the tubule becomes a compact mass of vacuolate tissue surrounding a vaguely defined central lumen (Fig. 9, A). This is especially so in the lower part of the tubule; the change is not so great towards the apex.

The two poison glands narrow gradually as they approach the base of the sting. Within the base of the sting, they usually become slender distinctly separated tubes, the acid gland above and the alkaline below, each surrounded at least in part by a com-

paratively thick mass of tissue, extensive in the alkaline gland, thin in the acid gland, especially on the dorsal surface. Only near their end do the two glands unite to form a nearly solid mass, much thicker below than at the upper part (Fig. 9, K). Near the apex much of this mass is formed of irregularly massed muscle tissue. The actual openings, narrow slits of crescent shape, are anterior to the lamellae of the sting sheath (Fig. 9, H).

AN ANNOTATED LIST OF THE LYCAENIDAE (LEPIDOPTERA: RHOPALOCERA) OF THE WESTERN HEMISPHERE

BY WILLIAM PHILLIPS COMSTOCK AND EDGAR IRVING HUNTINGTON

[CONTINUED]

schryneri, *Incisalia polios* Misspelling of *schryveri* Cross

Type Locality:

Location of Type:

Original Description: 1939, Zool. Record, vol. 75, p. 316 (London).

schryveri Cross, Frank C., *Incisalia polios*

Type Locality: Chimney Gulch, Colorado.

Location of Type: Cross Collection or Colorado Museum of Natural History.

Original Description: 1937 (July), Butterflies of Colorado, Proc. Colorado Mus. Nat. Hist., vol. 16, p. 20, no. 1 (Denver, Colorado).

Note: Probably a distinct species.

Synonyms: *schryneri* (Zool. Record).

scopas Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Jalapa, Mexico.

Location of Type: British Museum (Natural History) (Schaus Collection).

Original Description: 1887 (September), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 89, vol. 3, pl. 58, fig. 5 ♂ (London).

scoteia Hewitson, W. C., *Thecla*

Type Locality: Minas Geraes.

Location of Type: British Museum (Natural History).

Original Description: 1877 (January), Illus. of Diurnal Lepidoptera, vol. 1, p. 206, vol. 2, pl. 82, figs. 683, 684 ♂ (London).

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 594 (London). (Makes *scoteia* a synonym of *panchaea* Hewitson.)

scudderii Edwards, William H., *Lycaena*

Type Locality: Lake Winnipeg, Manitoba, Canada (♂ and ♀).

Location of Type: Lost (Nabokov).

Original Description: 1861 (July), Proc. Acad. Nat. Sci. Phila., p. 164 (Philadelphia, Pa.).

Additional References: Edwards, William H., 1862 (April), Proc. Acad. Nat. Sci. Phila., p. 225 (Philadelphia, Pa.). (Redescribes the female of *scudderii* presumably from specimens from London, C. W.). Nabokov, V., 1943, Phyche, vol. 50, p. 92 (Cambridge, Mass.).

Subspecies: *sweadneri* Chermock, *alaskensis* Chermock, *annetta* Edwards, *aster* Edwards, *empetri* Freeman, *fretchini* Chermock, *kodiak* Edwards, *subarcticus* Chermock.

sedecia Hewitson, W. C., *Thecla*

Type Locality: Mexico.

Location of Type: British Museum (Natural History).

Original Description: 1874, Ent. Mo. Mag., vol. 11, p. 105 (London).

Additional References: Hewitson, W. C., 1877 (January), Illus. of Diurnal Lepidoptera, vol. 1, p. 198, vol. 2, pl. 78, figs. 637, 638 ♂ (London). Mexico. Godman, F. D. and O. Salvin, 1887 (September), Biologia Centrali-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 94 (London). (Say that the type probably came from the West coast of Mexico. They give other Mexican localities and Guatemala.)

sedecia Hewitson, W. C., *Thecla*

Type Locality:

Location of Type: British Museum (Natural History).

Original Description: 1874 (December), Illus. of Diurnal Lepidoptera, vol. 1, p. 182, vol. 2, pl. 72, figs. 548, 549 ♂ (as *polibetes*) (London).

Note: This name is a homonym of *Thecla sedecia* Hewitson (1874, Ent. Mo. Mag., vol. 11, p. 105).

seitzi Spitz, Robert, *Thecla*

Type Locality: Murtinho, Matto Grosso, Brazil.

Location of Type: Museu Paulista, Sao Paulo.

Original Description: 1931, Revista de Entomologia, vol. 1, p. 48 (Sao Paulo, Brazil).

selica Draudt, Max, *Thecla* (not Hewitson). See *selika*

Type Locality:

Location of Type:

Original Description: 1919 (December), The Macrolepidoptera of the World, vol. 5, p. 768, pl. 152-e (Stuttgart).

selika Hewitson, W. C., *Thecla*

Type Locality: Brazil.

Location of Type: British Museum (Natural History).

Original Description: 1874 (December), Illus. of Diurnal Lepidoptera, vol. 1, p. 170, vol. 2, pl. 67, figs. 484, 485 ♂ (London).

selina Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1869 (April), Illus. of Diurnal Lepidoptera, vol. 1, p. 118, vol. 2, pl. 50, fig. 255 ♀ (London).

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 599 (London). (Points out the difference between *selina* and *pholeus* Cramer.)

semiluna Klots, Alexander B., *Satyrium fuliginosa*

Type Locality: Half Moon Ranch, Moose P. O., Jackson Hole, Wyoming.
Location of Type: American Museum of Natural History.
Original Description: 1930 (June), Bull. Brooklyn Ent. Soc., vol. 25, p. 161, figs. 5, 6 (Brooklyn, N. Y.).

semones Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Jalapa, Mexico.
Location of Type: British Museum (Natural History).
Original Description: 1887 (October), Biologia Centrali-Americanana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 98, vol. 3, pl. 58, figs. 20, 21 ♂ (London).

senta Draudt, Max, *Thecla*

Type Locality: Cañon del Tolima, Colombia.
Location of Type: Fassl Collection (1 ♂) (now in Naturhistorisches Museum, Basle).
Original Description: 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 783, pl. 156-a (Stuttgart).

separata Lathy, Percy I., *Thecla linus*

Type Locality: Rio Tono, Peru, 1200 ft.
Location of Type: Fournier Collection, Paris.
Original Description: 1926, Ann. Mag. Nat. Hist., Series 9, vol. 17, p. 42 (London).

sepium, *Thecla* Misspelling of *saepium* Boisduval

Type Locality:
Location of Type:
Original Description: 1880, Zool. Record, vol. 15, p. 185 (London).

septentrionalis, Lathy, Percy I., *Thecla ambrax*

Type Locality: Chontales, Nicaragua.
Location of Type: British Museum (Natural History).
Original Description: 1926, Ann. Mag. Nat. Hist., Series 9, vol. 17, p. 44 (London).
Additional Reference: Godman, F. D. and O. Salvin, 1887, Biologia Centrali-Americanana, Insecta, Lepidoptera-Rhopalocera, vol. 3, pl. 55, fig. 5 (ambrax) (London). (Selected by Lathy as type of *septentrionalis*.)

serapio Godman, F. D. and O. Salvin, *Thecla*

Type Locality: David, Panamá.
Location of Type: British Museum (Natural History).
Original Description: 1887 (September), Biologia Centrali-Americanana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 93, vol. 3, pl. 58, figs. 8, 9 ♂ (London).
Synonyms: *mesca* Dyar.

sergius Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Venezuela.

Location of Type: British Museum (Natural History).

Original Description: 1887 (September), *Biologia Centrali-Americana*, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 71 (London).

sesara Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Manaure, Colombia.

Location of Type: British Museum (Natural History).

Original Description: 1887 (September), *Biologia Centrali-Americana*, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 90 (London).

sesara Godman, F. D., *Thecla*

Type Locality: Las Vigas, Vera Cruz, Mexico.

Location of Type:

Original Description: 1901 (October), *Biologia Centrali-Americana*, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 722, vol. 3, pl. 111, figs. 7, 8 ♀ (London).

Note: This is a homonym of *T. sesara* Godman and Salvin, September, 1887.

sethon Godman, F. D. and O. Salvin, *Thecla*

Type Locality: Calderas, Guatemala (over 6000 ft.).

Location of Type: British Museum (Natural History).

Original Description: 1887 (September), *Biologia Centrali-Americana*, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 77, vol. 3, pl. 57, figs. 14, 15 ♂ (London).

setonia McDunnough, James H., *Strymon melinus* race

Type Locality: Seton Lake, Lillooet, British Columbia.

Location of Type: Canadian National Collection, no. 2502.

Original Description: 1927 (July), *Can. Ent.*, vol. 59, p. 160 (Orillia, Ont.).

seudiga Hewitson, W. C., *Thecla*

Type Locality: Brazil.

Location of Type: British Museum (Natural History).

Original Description: 1874 (December), *Illus. of Diurnal Lepidoptera*, vol. 1, p. 152, vol. 2, pl. 60, figs. 397, 398 ♂ (London).

shasta Edwards, William H., *Lycaena*

Type Locality: California.

Location of Type:

Original Description: 1862 (April), *Proc. Acad. Nat. Sci. Phila.*, p. 224 (Philadelphia, Pa.).

Synonyms: *calchas* Behr, *calcias* McDunnough, *nivium* Boisduval, *zelmira* Felder and Felder.

Subspecies: *comstocki* Fox, *minnehaha* Scudder.

sheltonensis Chermock, F. H. and D. F. Frechin, *Incisalia eryphon*

Type Locality: Shelton, Washington, April 26, 1947.

Location of Type: Carnegie Museum.

Original Description: 1948 (October), Pan-Pacific Ent., vol. 24, no. 4, p. 212 (San Francisco, Calif.).

sheridanii Auct. See *sheridonii*

Type Locality:

Location of Type:

Original Description:

sheridonii Edwards, William H. (in W. L. Carpenter), *Thecla*

Type Locality: Big Horn Mountains, Wyoming, July, 1877, 8000 ft.

Location of Type:

Original Description: 1877 (September), Field and Forest, vol. 3, p. 48 (Washington, D. C.).

Additional References: Strecker, Herman, 1878, Butterflies and Moths North America. A complete Synonymical Catalog, p. 186 (Reading, Pa.). (Lists the name as *sheridanii* W. H. Edwards.) Edwards, W. H., (1884), 1885 (February), A Revised Catalog of the Diurnal Lepidoptera of America North of Mexico, p. 57 (Philadelphia, Pa.). (Lists the name as *sheridanii* Edwards.) Clench, Harry K., 1944 (July), Bull. Mus. Comp. Zool., vol. 94, p. 228 (Cambridge, Mass.).

Note: The name *sheridanii* accredited to W. H. Edwards in lit. appears to have been first published by W. L. Carpenter as *sheridonii*, who said in his article that W. H. Edwards named the new species at his request.

Synonyms: *sheridanii* Auct.

Subspecies: *neoperplexa* Barnes and Benjamin.

shoumatoffi, Comstock, W. P. and E. I. Huntington, *Thecla celida*

Type Locality: Christiana, Jamaica, July 26, 1933.

Location of Type: American Museum of Natural History.

Original Description: 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 75 (New York).

Additional Reference: Kaye, W. J., 1931, Trans. Ent. Soc. London, vol. 79, p. 535, pl. 39, fig. 10 (London).

sibylla Kirby, W. F., *Cupido*

Type Locality: "Chili."

Location of Type:

Original Description: 1871, A Synonymic Catalogue of Diurnal Lepidoptera, p. 377, no. 323 (London). (Substitutes the name *sibylla* for the name *Lycaena endymion* Blanchard which he apparently considered to be a homonym of *Papilio endymion* Schiffermüller and Denis (Wien Verz., p. 182, no. 1, 1775)).

Additional Reference: Draudt, Max, 1921 (January), the Macro-lepidoptera of the World, vol. 5, p. 822 (Stuttgart). (Corrects Kirby's mistake and places "sybilla Ky." in synonymy of *endymion* Blanchard.)

Synonyms: *sybilla* Draudt.

BOOK REVIEWS

A REVISION OF THE NEW WORLD SPECIES OF THALYCRA ERICHSON, with a description of a New Genus and Notes on Generic Synonymy (Coleoptera: Nitidulidae). Henry F. Howden, Entomology Research Institute, Research Branch, Canada Department of Agriculture, Ottawa, Ontario. *The Canadian Entomologist*, Supplement 25, 1961, 61 pp.

This is a thorough revision of the 16 New World species of the sap beetle genus *Thalygra* and includes a description of a new closely related monotypic genus *Pseudothalygra*. Keys, synonymies, diagnoses, descriptions, distributional data, distributional maps, and comparative illustrations of diagnostic features are presented.—JEROME G. ROZEN, JR.

THE NEST ARCHITECTURE OF THE SWEAT BEES. A Comparative Study of Behavior. Shôichi F. Sakagami and Charles D. Michener. The University of Kansas Press, Lawrence, 1962, 135 pp., figs. 1-181, price \$5.00.

The sweat bees, whose common name is derived from their frequent habit of lapping perspiration from their skin, constitutes the subfamily Halictinae of the Halictidae, with approximately 2000 known species. This group is unique in the occurrence among its various species of a continuous spectrum from strictly solitary to fairly complicated social behavior. Consequently, these bees offer an unexcelled opportunity to study the evolution of social organization, one major aspect of which is nest structure.

The main purpose of this thin, easily read book is to compare and summarize the previous knowledge of the nest structure and function and to add previously unreported information. The introductory chapter deals with certain philosophical aspects of the interrelationship of comparative behavior and taxonomy. The following main subjects are dealt with by chapter: nest-site preference, gregariousness, nest elements other than brood cells, arrangement of brood cells, brood cells, winter shelter, utilization of pre-existing structures, classification of nest patterns, relationship between architecture and taxonomy, and relationship between architecture and social organization. Over 150 papers are listed in the bibliography.—JEROME G. ROZEN, JR.

OUR GARDEN FRIENDS THE BUGS. Allan W. Forbes. Illustrated by Lili Réthi, F.R.S.A. Exposition Press, N. Y., published June 1962, 190 pp., price \$4.00.

Entomologists often look longingly to the past when observation of nature was a common avocation and when amateurs spent their leisure hours studying insect life in gardens and woodlands. These hobbyists gave their support to conservation movements and to professional advances.

This small book, written by an amateur, follows this tradition. It makes a strong plea for more study of the biology and food habits of insects and for biological rather than chemical insect control. Its author, Allan W. Forbes, is a retired engineer who has watched "the bugs" and has successfully staged a one-man stand for biological control of his small garden plot. Many of the garden insects are discussed. Common names abound, but deviation from approved designations sometimes leads to confusion.

The tendency of the author to interpret insect and animal behavior anthropomorphically and to form strong opinions about these creatures without scientific proof is a detracting element in Mr. Forbes' presentation.

The illustrations by Lili Réthi are placed at appropriate intervals through the text and are adequate. Most of them are habitat sketches.—J. FORBES

THE STRANGE LIVES OF FAMILIAR INSECTS. Edwin Way Teale. Illustrated with photographs by the author and drawings by Su Zan Swain. Dodd, Mead & Company, published October 1962, 208 pp., price \$4.00.

Edwin Way Teale has dedicated this latest book "to J. Henri Fabre, whose books opened the door to popular interest in the living insects." This new volume is another contribution to the continuing effort to keep that door wide open. The printed page takes one on a leisurely trip through woods and fields to the habitats of familiar insects. The writing stems from a sensitivity to nature and happily combines enthusiasm for the insect world with scientific fact. Amateurs will find learning about insects a pleasant adventure; the more-experienced will enjoy a visit with some old acquaintances in a fresh format.

Three areas of insect information are explored in three parts of the book. A small section, "The Strangeness of Insect Life," whets the reader's appetite with bits of information obviously chosen to fascinate. Part II, "What Life Is Like for an Insect," is concerned with fundamental activities in the insect's day-to-day life. Here one finds general information about how an insect eats, sleeps, moves about, flies, uses its senses, etc. Three-quarters of the book is devoted to Part III, "Lives of Familiar Insects"; fourteen insects representing eleven orders are individually treated. Background information is interwoven with brief but rather complete life histories so as to give each insect a personality of specific activities, economic importance, place in history, and even pertinent quotes from literature.

There are 16 full pages of expert photographs by the author. These camera studies bridge the gap between the word descriptions and reality and add considerably to the eye-appeal of the volume. Additional illustrations are provided by the artistic and detailed drawings of Su Zan Swain, which head each chapter.—J. FORBES

Recent Publication

A LIST OF THE APHIDS OF NEW YORK by Mortimer D. Leonard, Proc. Rochester Acad. Sci., 10:6:289-428, 4 pls., Feb. '63, paper covers, \$1.50. Included are life histories, economic importance, method of feeding, production of winged forms, productivity, rôle as vectors of plant viruses, distribution records of 350 species and over 700 food plants.

PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF OCTOBER 4, 1960

President Shoumatoff called the meeting to order at 8:05 P.M. in Room 129 of the A. M. N. H. The minutes of the previous May meeting were approved as read. Twenty-six members and five guests were welcomed to this first meeting of the season. The President announced the sad passing, just two days before, of our fellow-member, Herbert Schwarz. Mr. Huntington, a friend and colleague of Mr. Schwarz, spoke of their long association, of their field trips together with Dr. Lutz, and concluded with the tribute, "He was the kindest man I ever met." The following resolution, prepared and read by Dr. Asher Treat, was approved by the members:

"In the death of its Honorary Life Member, Herbert F. Schwarz, The New York Entomological Society knows the most painful loss that it could possibly experience. Few of our members have

matched his scientific achievements, fewer his kindness, and none his selfless modesty. Having no paltriness in himself, he could see none in others. When the Society prospered he rejoiced with us, when we faltered he sustained us, when we erred he claimed our faults as his own. In his long devotion to the finest traditions of science and of humanity he has left us a legacy which we must cherish even above all his other beneficence, and for which we shall gratefully remember him as long as any of us shall meet together.

"Therefore be it resolved that this record of our profound regret at the passing of our beloved fellow-member be spread upon the minutes of the Society, and be communicated, together with our deepest sympathy, to the members of his family."

President Shoumatoff stated that a few days before his death, Mr. Schwarz had made a gift of a thousand dollars to the Society.

The President announced that Dr. Treat's report as our official delegate to the XIth International Congress of Entomology held in Vienna during August would be made at a future meeting. It was mentioned that Roman Vishniae had received a large federal grant to produce 18 educational films for the Government.

Miss Alice Gray of the Entomology Department of the Museum was welcomed back from her year in California. She started the program of the evening, **The Members' Summer Experiences**, with a description of her studies on the Protura. Dr. Ruckes spoke of his European trip, some of the entomologists he met, and a visit to the home of Linnaeus. Dr. and Mrs. Klots visited Michigan, England, and the continent for the Entomological Congress. Dr. Klots showed how the European zygaenid, now immune to cyanide, is killed with nicotine taken from the end of a well-chewed cigar and injected by means of a pin. Mr. Peter Dix showed slides of a field trip to the Pine Barrens in New Jersey and some pictures taken in Europe while attending the Entomological Congress. Mrs. Alice Hopf had a picture of a Monarch butterfly pupae in a leaf. Dr. Edwin Teale showed a few pictures of an unusual and unidentified bee. Mr. Lucian Pohl gave a brief but interesting resumé of his travels through Japan, India, Turkey and, of course, France.

The meeting adjourned at 10:00 P.M.

RAYMOND BRUSH, SECRETARY

MEETING OF OCTOBER 18, 1960

The President called the meeting to order at 8:00 P.M. in Room 129 of the A. M. N. H.; 20 members and 11 guests were present. The minutes of the previous meeting were accepted with corrections. Dr. Jerome G. Rozen, Jr., the Chairman of the Department of Entomology of the Museum, was proposed for membership. He was immediately accepted into the Society when it was unanimously approved to suspend the By-Laws. Mr. Peter Dix showed a few slides of Bedford Village illustrating the area where one of our field trips was held.

Dr. Klots introduced the speaker of the evening, Dr. Charles Vaurie, of the

Ornithology Department of the Museum, who gave an interesting talk on "Collecting in the Caribbean" illustrated with beautiful colored slides. Doctor and Mrs. Vaurie had been sent by the Entomology Department of the Museum to collect insects and spiders in Martinique, Guadeloupe, and Jamaica. He spoke on the zoogeography of the West Indies and mentioned that the fauna was poor in comparison with continental faunas. Many weevils and spiders were collected, including the endemic weevil, *Exophthalmus*, which is so variable that eight species have been described where there is probably only one. Economically important weevils, *Metamasius*, *Lachnopus*, etc. are abundant in some parts. The little known Islands of the Saints and H.M.S. Diamond were visited. A representative collection of some of the beetles collected were shown.

The meeting adjourned at 10:00 P.M. after a short discussion period.

Raymond Brush, *Secretary*

MEETING OF NOVEMBER 1, 1960

The President called the meeting to order at 8:05 P.M. in Room 129 of the A. M. N. H. The minutes of the previous meeting were accepted. Mr. Shoumatoff announced that a new fund has been started in the name of the late Mr. Schwarz. He appointed Dr. Edmund R. Janvrin as the new trustee filling the vacancy left by Mr. Schwarz. An announcement from Dr. Frederick H. Rindge of the Museum stated that the Annual Meeting of the Lepidopterists' Society for 1960 has been transferred from Ottawa, Canada, to the American Museum in New York, on Wednesday, December 28th, the week of the AAAS meetings in New York.

Doctor Asher Treat, the first speaker of the evening, gave his report as the Society's delegate to the XIth International Congress of Entomology which was held in Vienna this past August. He commented on the papers he heard and the films he saw and thanked the Society for the opportunity to serve as its delegate.

Dr. Treat then introduced Mr. and Mrs. Peter Belton who are here from Glasgow, Scotland to continue their work on the insect tympanic organs. Mr. Belton talked on "Electron Microscopy of the Insect Ear." His talk was illustrated by slides on the anatomy and histology of the locust tympanum. The substance collagen has been found here although it is rare in insects. The 70-80 sensory units in each ear are oriented in 3 mutually perpendicular axes. Many questions were asked of the speaker. (An abstract follows).

The meeting adjourned at 9:30 P.M.

PETER DIX, SECRETARY, PRO TEM.

Electron Microscopy Of The Insect Ear: A Review.

A recent electron microscope study carried out by E. G. Gray (1960, The fine structure of the insect ear. Phil. Trans. Roy. Soc., B, 243: 75-94.) has resolved many of the problems of the structure and relationships of the cells that make up the sensory unit (sensillum) of the locust ear. The fine distal process of the bipolar neuron which is present in each sensillum re-

sembles a cilium in ultrastructure. It remains to be determined whether this type of ultrastructure, which is also found in non-motile sensory cells of many other animals, represents a structural, functional or evolutionary relationship. Motile cilia are thought to be lacking throughout the insect class.

Mechanical energy is converted into nerve impulses somewhere in the sensory unit but the site of this conversion is not revealed by electron microscopy since it is impossible to determine which components move in respect to one another. However, the information obtained from these ultrastructural observations makes it possible to construct models which will convert mechanical energy into electrical changes and these models can be tested critically in future anatomical and physiological investigations.

PETER BELTON

MEETING OF NOVEMBER 15, 1960

President Shoumatoff called the meeting to order at 8:05 P.M. in Room 129 of the A. M. N. H. An overflow crowd was on hand and the meeting was moved to Room 419. The minutes of the previous meeting were approved as read. It was announced that the Schwarz Memorial Fund has reached \$110. Miss Alice Gray spoke about the Junior Society and said that the group had had one meeting and one field trip on which she had found some Protura. Their next meeting, on November 26th, will be a business meeting. This group is interested in starting an entomology course.

Dr. Klotz introduced the speaker and exhibitor of the evening, Dr. Edwin Way Teale, who talked about the "Tenants of an Old Farm." His talk was illustrated with his remarkable color slides depicting the 79 acres of his recently acquired farm in north-eastern Connecticut; the house, grounds, trees, driveway, fields, woods, flowers, insects, and other animals to be found thereabouts. Even a bee in flight had been photographed. After the showing Dr. Vishniac made complimentary remarks, followed by Dr. Schneirla, who commented on the *Camponotus* ants and their pupae which had been shown in one picture.

The meeting adjourned at 10:00 P.M.

PETER DIX, SECRETARY, PRO TEM.

MEETING OF DECEMBER 6, 1960

The President called the meeting to order at 8:00 P.M. in Room 129 of the A. M. N. H. There were 23 members and 34 guests present. The minutes of the previous meeting were accepted as read. Three proposals for membership were made: Robert C. Wagner, Frank Rutkowski, and Iona Deur. Mr. Shoumatoff read a letter of thanks for the Society's expression of sympathy from Mrs. Herbert Schwarz.

President Shoumatoff introduced the speaker of the evening, Mr. John C. Pallister of the Museum staff, whose subject was "Wanderings of a Naturalist Photographer." Mr. Pallister's beautifully illustrated wanderings took us from the sandy beaches of the New Jersey coast to Yucatan and South America. Included were the tiger, longhorn, elephant, goliath,

dung, and click beetles. We saw wonderful examples of the larvae and adult ant lions, cicada killers with their victims, may-flies, dragon-flies, cockroaches, tarantulas, millipedes, centipedes, scorpions, wasps, and mantids in various stages of their growth. Toads, snakes, and vultures were not neglected either. There were pictures of carnivorous plants and excellent slides of lepidoptera. All were interestingly described by Mr. Pallister.

A short question and answer period was followed by adjournment at 10:00 P.M.

RAYMOND BRUSH, SECRETARY

MEETING OF DECEMBER 20, 1960

Mr. Shoumatoff called the meeting to order at 8:15 P.M. in Room 419 of the A. M. N. H. There were 22 members and 12 guests present. The minutes of the previous meeting were accepted as corrected. The President thanked Mrs. Vaurie for her help in getting out the meeting notices. Messrs Wagner and Rutkowski and Miss Deur were elected to membership in the Society and Mr. Albert J. Posel was proposed by Mr. Shoumatoff. Suggestions for appropriate use of the Herbert Schwarz Memorial Fund were made by Dr. Teal and Mr. Brush; these and others will be considered by the Executive Committee. Our new member Miss Deur, a professional artist, showed some examples of her newest work with insect subjects. Dr. Louis Marks announced that Dr. Roman Vishniac would address a meeting of the AAAS at the Roosevelt Hotel, Thursday, December 29th, and that the Lepidopterists' Society's Annual Meeting would be held at the A. M. N. H. at 10:00 A.M., Wednesday, December 28th.

Mr. Shoumatoff introduced Miss Alice Gray, our fellow member and sponsor of The Junior Society and a member of the Entomology Department of the Museum, who arranged the program for the evening. Miss Gray then introduced Miss Hertha Taussky, a bio-chemist by profession, whose hobby is the Ladybug in art. Miss Taussky told how she became interested in the subject and of the many meanings attributed to this insect throughout the world. Her collection represented the Ladybug on leather goods, greeting card, pill boxes, thimbles, lighters, candles, all sorts of pamphlets, compacts, and even a dog-collar. This interesting and varied collection came from more than 12 different countries. She described some of her collection in detail for us.

Miss Gray then presented her collection of insects in art and explained the decorative and symbolic importance of some of the items. These varied from Egyptian scarabs to Origami, the Japanese art of paper folding, and included insects of all kinds made of wicker, raffia, palm leaves, a gourd pit, wood, glass, iron, ceramics, bamboo, and candy. Among the articles were toys, Christmas tree ornaments, textiles, and the jewelry from all corners of the globe.

Both displays were tastefully exhibited so that all present could examine the fascinating articles at greater length after the talks.

Cookies in the form of insects, including multi-colored butterflies, courtesy of Mrs. Heineman, were served with cold cider. This added a note of

holiday spirit to a most entertaining meeting which adjourned at 10:00 P.M.
RAYMOND BRUSH, SECRETARY

MEETING OF JANUARY 3, 1961

President Shoumatoff called the Annual Meeting to order at 8:00 P.M. in Room 319 of the A. M. N. H.; 24 members and 27 guests were present. The minutes of the previous meeting were accepted as read. Mr. Heineman was called upon for his report as Program Chairman. He listed many of the coming programs. The Tresurer reported a bank balance of \$1200.00 and about \$4000.00 in the Capital Fund; the Society has 116 members and 215 subscribers to the JOURNAL. Our Editor, Dr. Creighton, reported that the latest issue of the JOURNAL would arrive in the very near future, and that he has a good supply of papers for future issues. Miss Alice Gray announced that the Junior Society would be having their annual meeting soon. Mr. Albert Posel was elected to membership.

The President turned the meeting over to Dr. Asher Treat to conduct the elections. Dr. Treat proposed a standing vote of thanks to President Shoumatoff in appreciation of his successful handling of the Society's affairs. This was enthusiastically acted upon. The Nominating Committee, consisting of James Forbes, Lucian Pohl, and Lucy Clausen, Chairman, submitted the following slate of officers:

President	Dr. John B. Schmitt
Vice-president	Dr. Elsie Klots
Secretary	Mr. Raymond Brush
Assistant Secretary	Mr. Peter Dix
Treasurer	Mr. Jacob Huberman
Assistant Treasurer	Mrs. Patricia Vaurie
Editor	Dr. William S. Creighton
Associate Editor	Dr. James Forbes
Publication Committee	Mr. E. Irving Huntington Mr. Bernard Heineman Mr. Frank Soraci
Trustees	Mr. Lucian Pohl Dr. Daniel Ludwig Dr. Asher Treat

No further nominations were presented and the Secretary was empowered to cast one ballot for the entire slate. Dr. Schmitt, welcomed as our new President, expressed his thanks to the membership.

Mr. Shoumatoff presented Dr. Roman Vishniac, the speaker of the evening. Dr. Vishniac, a past-president of the Society and a noted photographer, spoke on "The Search For Living Biology." He reiterated his dislike for the killing bottle and his admiration for observing the living animals. He showed two color movies of fresh water and marine organisms which were magnificent. The tremendous magnification of these pictures, photographed under natural conditions in their actual environments, have to be seen to be believed. Dr. Vishniac has received a grant from National Science Foundation to further this work.

The meeting adjourned at 10:00 P.M.

RAYMOND BRUSH, SECRETARY

MEETING OF JANUARY 17, 1961

President Schmitt called the meeting to order at 8:00 P.M. in Room 129 of the A. M. N. H.; 16 members and 10 guests were present. The minutes of the previous meeting were accepted as read. Miss Alice Gray showed a beautiful scarf on which were printed specimens of pinned insects. Miss Deur proposed Mrs. Gaston Dubois for membership. Dr. Schmitt then read a letter from a member, who prefers to remain anonymous, who has offered to pay the 1962 dues for the next 25 new student members to join the Society and who paid their own 1961 dues. This offer is to be called to the attention of all members having contact with interested students.

Dr. Roman Vishniac then introduced our fellow-member and former President, Dr. Lucy Clausen, who spoke on "Insects and Human Status." She started her talk with a vivid account of a ceremony of the South American Arawak Indians to prove their fitness for marriage. A device containing biting red ants is placed on tender parts of the bodies of 11 and 12 year old children. They must withstand this torture for long periods of time. Older persons go through the same ordeal to prove their bravery and to improve their prestige. She related how young men of Bedouin tribes eat quantities of live scarab beetles to show their right to enter manhood. This led to stories of scarabs and what these insects have meant to many ancient peoples. Some New World Indians revere cicadas, mole crickets and use insects as medicines. Her very interesting talk described the part insects have played in societies in terms of status religion, and mortality. Her closing remarks referred to the researches of Morgan, Ross, and Reed on insects. The discussion after the talk led to modern household insects and the cockroach.

Dr. Vishniac then exhibited and described items from his art collection. These included ancient Japanese sword-guards, scabbards, daggars, and medicine bottles all of which had some form of insect motif. All were admired.

The meeting adjourned at 9:45 P.M.

RAYMOND BRUSH, SECRETARY

Communications

Dr. Alvaro Wille, in a letter received too late for publication in the **Journ. N. Y. Ent. Soc.**, 70, wishes two corrections noted:

1. on page 229 locality should read: "collected by Th. Dobzhansky in the mouth of the Cuiari River, Amazonas, Brazil."
2. on page 234 (Literature Cited)—The Moure citation should read: Moure, Jesús, 1953. *Nogueirapis*; novo group . . . Ciencia e Cultura, São Paulo, etc.

Dr. Paulo Nogueira-Neto wishes two corrections noted for his paper published in the **Journ. N. Y. Ent. Soc.**, 70, as follows:

1. on page 244, the period between brackets (Five or six hard hyaline grains, etc.) should be placed as an independent paragraph.
2. on page 249, change: "In this region, cutting through . . . were a cluster of honey pots" to read: "In this region, after cutting through . . . I saw a cluster of honey pots."

**JOURNAL
of the
NEW YORK ENTOMOLOGICAL SOCIETY**

The JOURNAL of the NEW YORK ENTOMOLOGICAL SOCIETY is devoted to the advancement and dissemination of knowledge pertaining to insects and their related forms.

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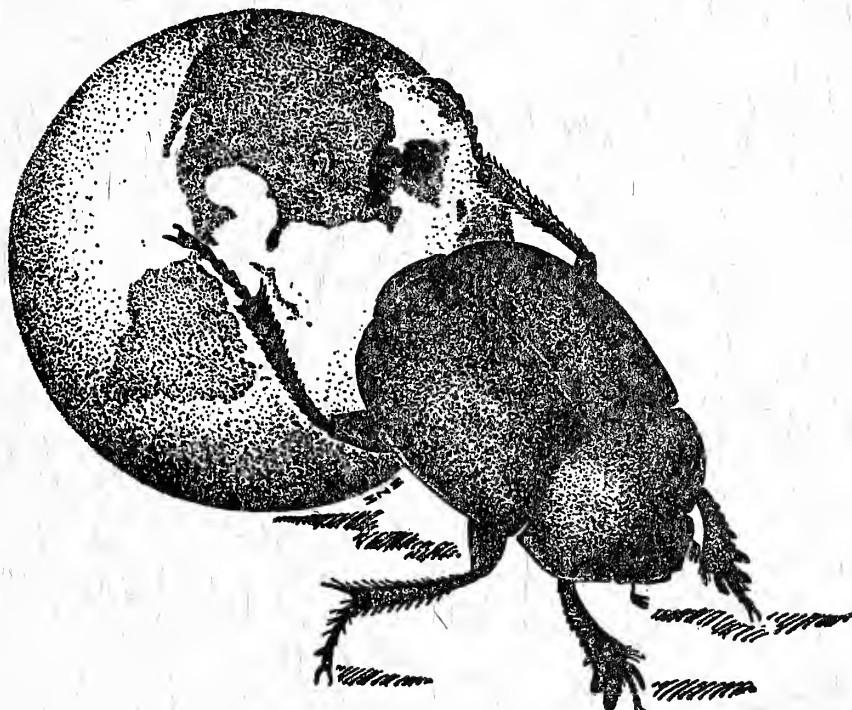
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SUBTERRANEAN NESTS OF TWO AFRICAN STINGLESS BEES (HYMENOPTERA: APIDAE)¹

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RECEIVED FOR PUBLICATION SEPTEMBER 7, 1962

ABSTRACT

Descriptions of the nests of two African subterranean meliponid species, namely, *Melipolebia tanganyikae medionigra* (Cockerell) and *Plebeiella lendliana* (Friese) are given. In both species, the nest proper consisted of brood area, area of old cerumen layers, and of pollen and honey pots. The combs are horizontal in both species, the mode of building is concentric in *M. t. medionigra* while clockwise-spiral in *P. lendliana*. In both species, the nests are connected to the exterior by means of an entrance burrow, of which the uppermost section forms a turret protruding above the soil surface. An interesting lower blind burrow was observed in *M. t. medionigra* apparently for the drainage of excess moisture. Both species can be transported to artificial hives, but the maintenance of the colonies under this condition is difficult.

While subterranean stingless bees have been studied in Brazil since von Ihering (1903), African species of similar habit have received little attention until recently (Smith 1954). The present paper deals with the subterranean nests of two species observed in Angola.

MATERIAL AND METHODS

All nests observed, seven colonies of *Melipolebia tanganyikae medionigra* (Cockerell 1934) and four of *Plebeiella lendliana* (Friese 1900),⁴ were collected in the plateau areas of Districts

¹ The present work was made under the financial aid of the Direção de Agricultura e Florestas de Angola and of the Rockefeller Foundation.

² Técnico Apícola da Direcão de Agricultura e Florestas de Angola. Present address: Dept. General Biology, Faculdade de Filosofia, Ciências e Letras de Rio Claro, Brazil, under a Studentship of the Portuguese Government and of the Rockefeller Foundation.

³ Submitted for inclusion in the **Herbert F. Schwarz Memorial Volume** (1962) but delayed in publication due to lack of space, cf, 70 p. 214.

⁴ The scientific names were used according to the system of Moure (1961). In a more conservative treatment, these would be written as *Trigona (Melipolebia) tanganyikae medionigra* and *Trigona (Plebeiella) lendliana*, respectively.

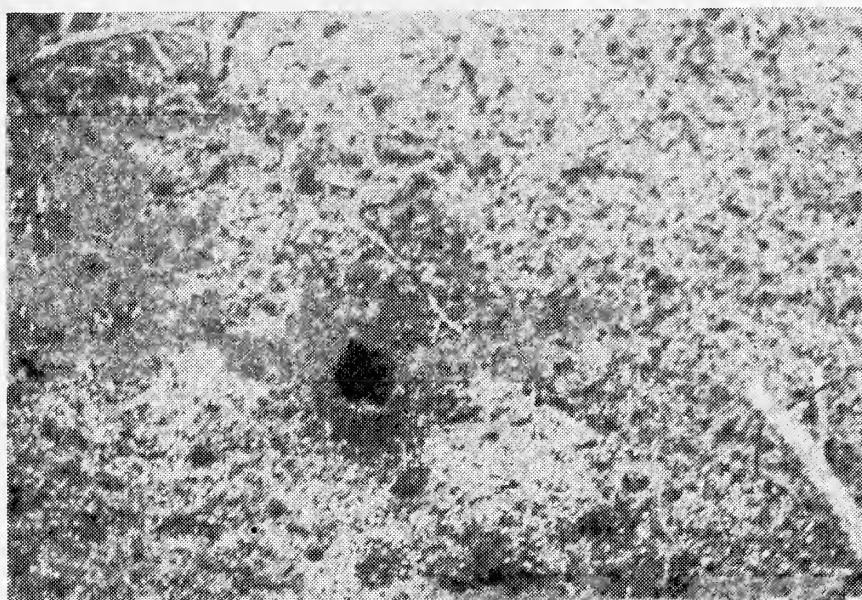


Fig. 1—Entrance of a nest of *Meliponella tanganyika medionigra* (entrance of nests of *Plebeia lendliana* have a similar structure).

Moxico and Huila, Angola, where the dominant soil types are arenaceous or argilo-arenaceous. All were discovered in grassland areas but never within forests. Except for one colony of *P. lendliana* recovered from a termitarium, all nests examined were found in subterranean cavities. One nest was sent by air from Huila (2,000 m alt.) to my laboratory in Luanda (sea level) where it lived from 1956 to 1958 in a wooden box.



Fig. 2—Excavation of subterranean nest; (notice vertical straw introduced through entrance burrow).

The entrances are usually so well hidden under grasses and weeds (Fig. 1) that they are discovered only by chance. Hence, information brought by the natives is indispensable for collecting the nests. After the discovery, a flexible stick is introduced through the nest entrance, then, the nest is dug out (Figs. 2 and 3).



Fig. 3—A colony of *Melipolebeia tanganyikae medionigra* entirely exposed (1.80m in depth). The upper part of the entrance burrow was damaged during excavation.

OBSERVATIONS ON *M. tanganyikae medionigra*

The nest structure of *Melipolebeia* was already described by Smith (D.C.) in *M. beccarii*. But the architecture of *M. tanganyikae medionigra* (called Uky in Kioko dialect) observed by me showed some differences from that in *M. beccarii*, so that it deserves a description here.

The nests are usually found between 0.5 to 1.0 m below soil surface and connected to the exterior by a vertical or slightly inclined burrow. The nest is pear, calabash or fig-shaped, 25 to 35 cm high by 30 cm in diameter (Figs. 4, 5 and 6). The

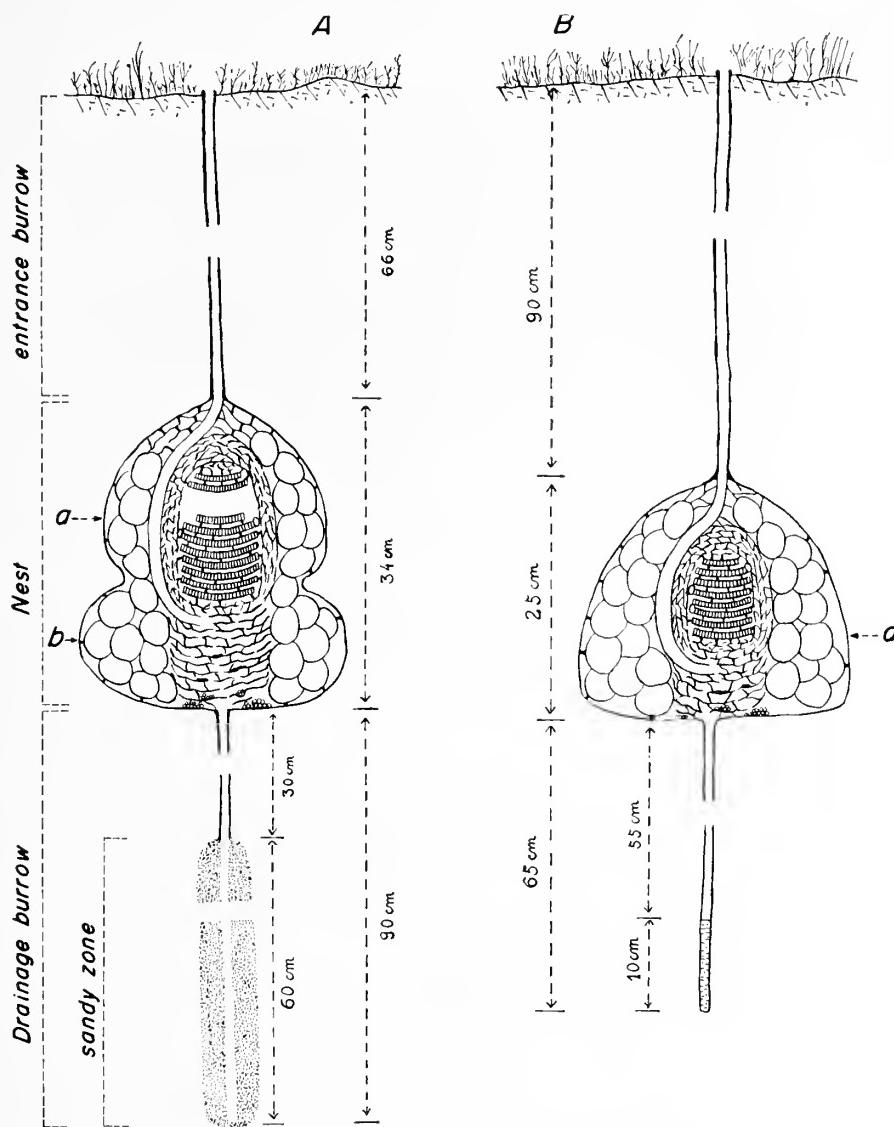


Fig. 4—Two nests of *M. tanganyikae medionigra*. Vertical entrance burrow in both A and B.

A = Calabash shape nest with drainage burrow opening into sandy zone.
B = Fig-shape nest with blind drainage burrow, filled with milky dirty water. It may be that this is a nest with just the *a* part built, and that latter on the bees would construct the *b* part.

walls are not smooth, lined with dark propolis 1 to 2 mm in thickness. Within the nest three distinct areas are observed: the brood area, the area of old cerumen layers and the area of pollen and honey pots. The brood area is cylindrical with round

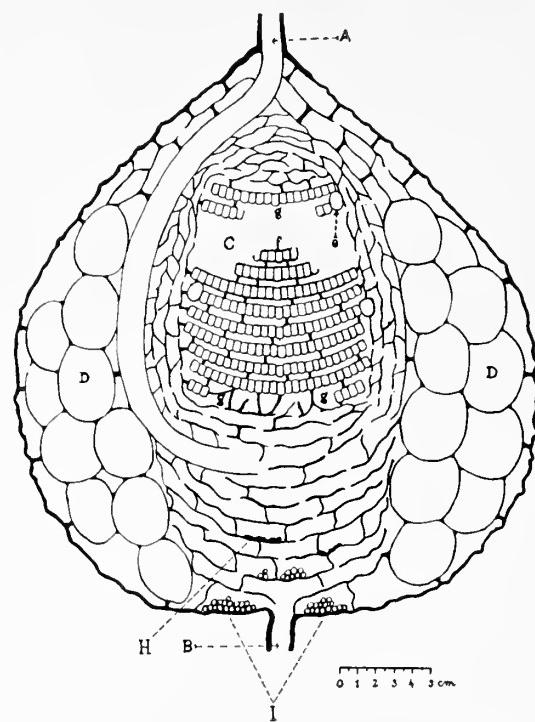


Fig. 5—Nest of *M. tanganyikae medionigra*. A = entrance burrow; B = drainage burrow; C = brood area; D = honey and pots; e = royal cell; f = combs being built; G = brood combs, in the central area young bees are emerging; H = resin; I = garbage area.

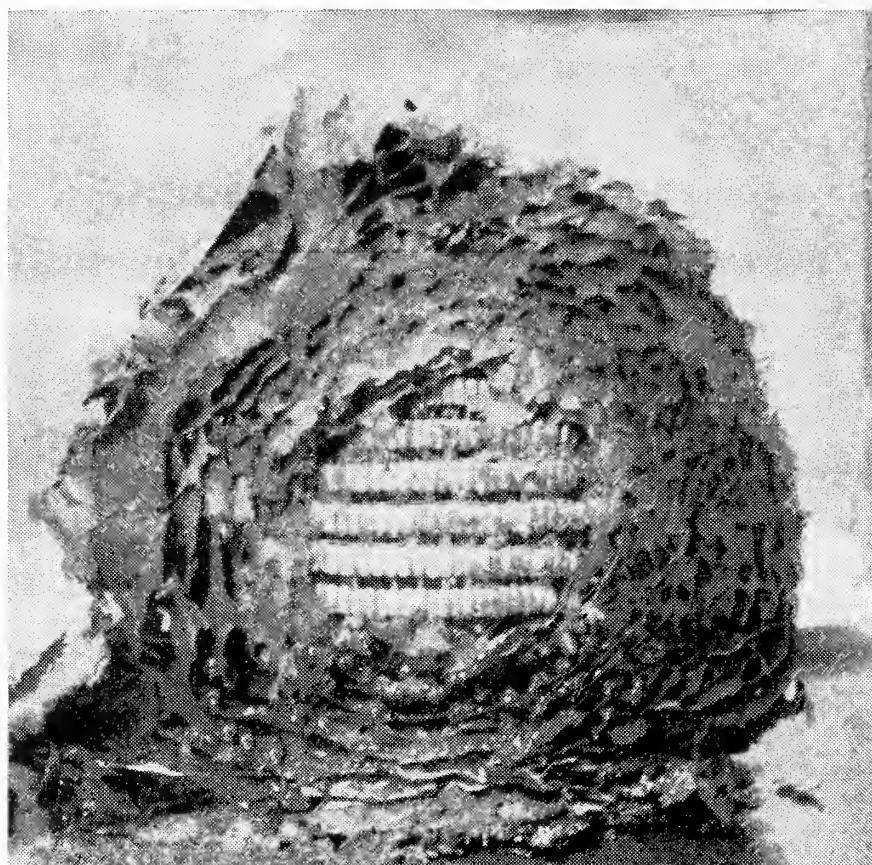


Fig. 6—Nest of *M. tanganyikae medionigra* with large membranous involucrum. Note entrance tube opening below the brood area. Brood combs are intact but pots were removed before photographing.

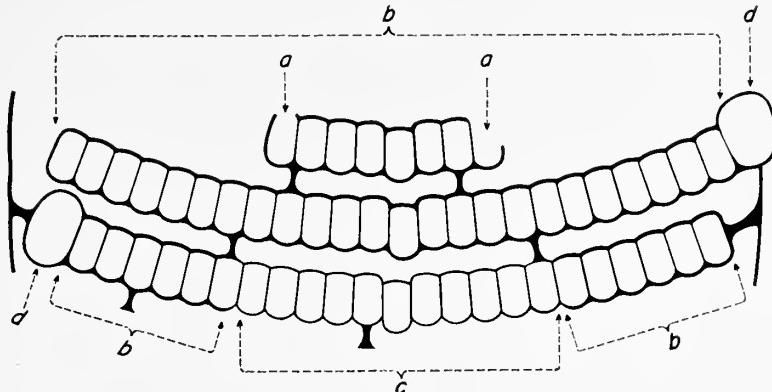


Fig. 7—Three brood combs of *M. tanganyikae medionigra*, side view, showing: a = cells in construction; b = cells with larvae; c = cells with prepupae and pupae, in which wax was removed at the tops; d = royal cells.

bottom, waxy above but hard below, externally about 18cm high by 14cm in diameter while internally 12cm by 9cm. These differences are caused by the occurrence of the involucrum, consisting of 4 to 10 waxy sheets. The outer sheet is almost completely smooth, leaving only small holes which serve as pathways for bees. Within the involucrum, 8 to 12 horizontal brood combs

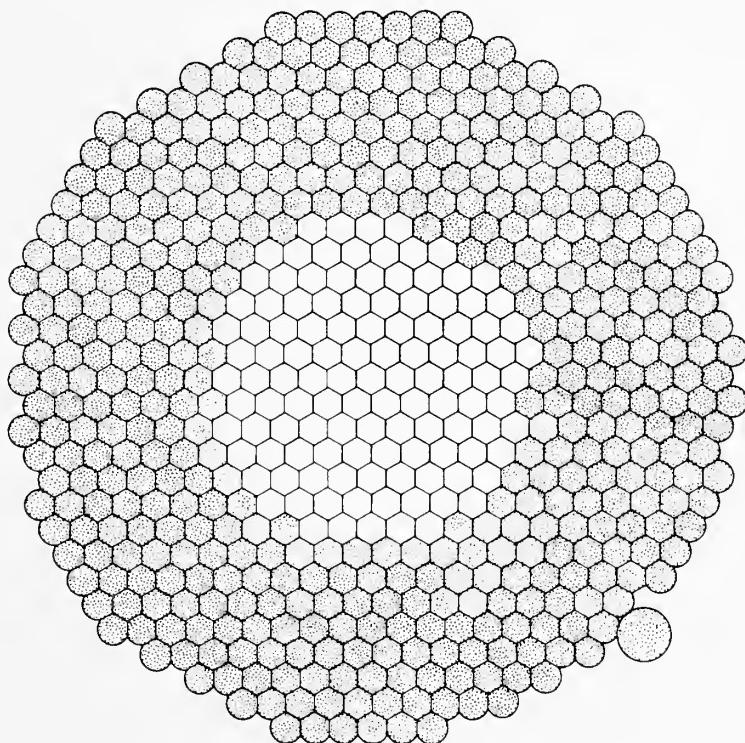


Fig. 8—Comb of *M. tanganyikae medionigra*, seen from above. Light central area are cells with prepupae and pupae from which wax was removed at the tops; dotted area represents region where young larvae and eggs (in the periphery) are found. Left side indicates royal cell.

are found. Each comb is at first horizontal but later becomes concave, the central cells about 1mm lower than the peripheral ones (Fig. 6). Nothing is known about why the combs become concave although built horizontally. The maximum diameter of combs so far recorded was 13cm. A comb of 10cm in diameter may contain about 450 cells (Fig. 7). The mode of the construc-

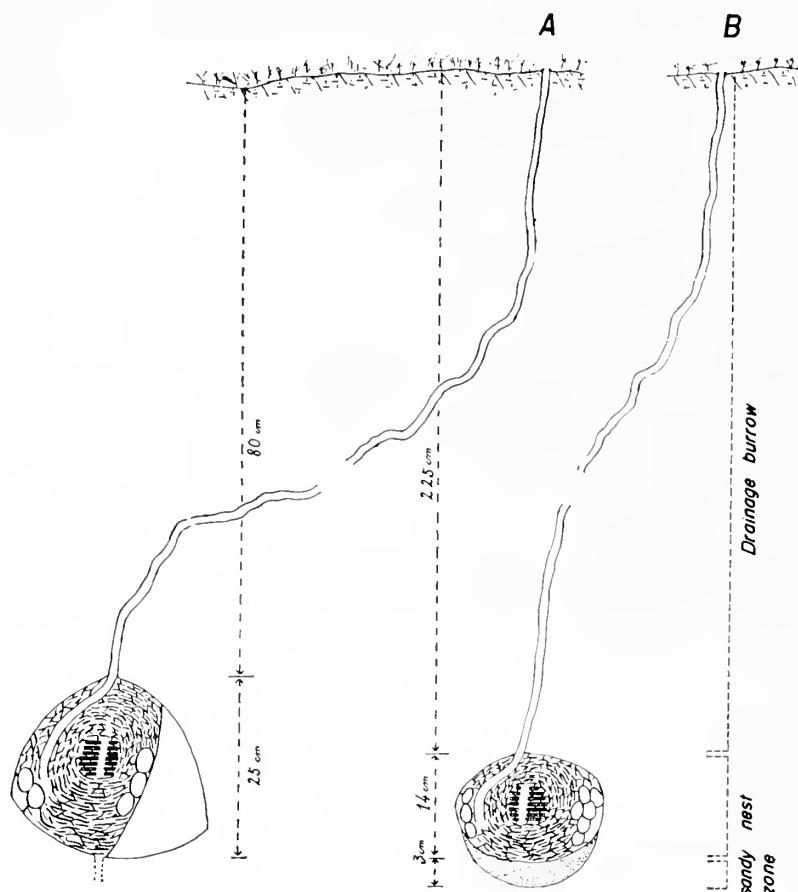


Fig. 9—Two nests of *Plebeia lendliana*. Notice in both A and B nests the inclined irregular entrance burrow.

A = This nest was partially built in a termitarium pan and has a drainage burrow.

B = This nest was built directly on a sandy zone, with no drainage burrow.

tion is concentric, that is, each comb is made from center to periphery. Very often each comb is firmly connected to one another or with involucrum by means of waxy columns. Each cell is 7mm high by 3.8 to 4mm in diameter, rounded both at top and bottom, though the former is less convex. After the larvae spin the cocoons, the workers expose them by taking out the wax from the surface of cells, a trait well known in the bumblebees and, probably common to all stingless bees and described by Kerr (1949) in several stingless bees.

The area with old cerumen layers is immediately below the brood area, and of the same diameter. The entrance burrow opens into the upper part of this area. Garbage and resin deposits are found in the lower area. The opening to the lower blind burrow is found at the center of the bottom. The area of pollen and honey pots cover the brood area laterally. Each pot is an average 3 to 4 cm high and 2.5 to 3.2 cm in diameter. In general the pollen pots are placed nearer to the brood area than the honey ones. One of the nests examined contained about 2 liters of agreeable honey.

The entrance burrow is either vertical or slightly inclined,

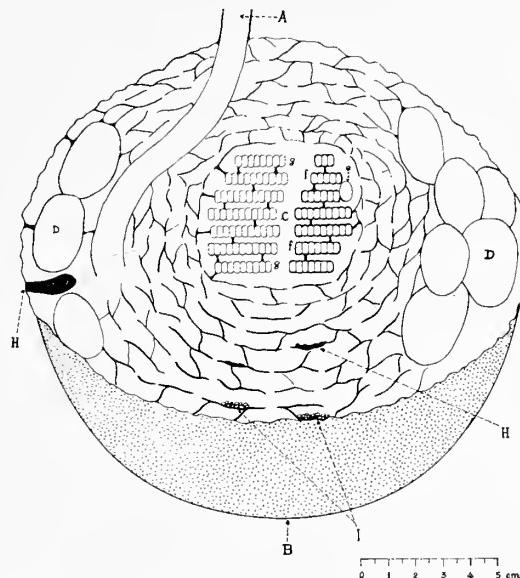


Fig. 10—Nest of *P. lendliana*, showing: A = entrance burrow; B = sandy area for drainage; C = brood area; D = honey and pollen pots; e = royal cell; f = cells in construction, cells with eggs and young larvae; g = cells with pupae and imago; H = resin and gum deposits; I = garbage area.

50 to 100 cm in depth, protruding above the soil surface and forming a turret of about 1.0 to 1.5 cm in height: the internal diameter is 8 to 10 mm and the walls are lined with dark and hard propolis 1 to 2 mm in thickness though thicker near the nest proper.

At the center of the bottom of the nest proper, is found the entrance to a characteristic blind burrow, which is deep (95 cm in one case), reaching to the sandy zone or opening to a cavity either empty or filled with sand. The walls of this burrow are lined with propolis in its upper section and easily distinguished from the lower section. But in one nest, the burrow was lined

with propolis throughout its extent and was filled with white liquid. When the blind burrow opened to the sandy zone, the sand was full of moisture. This burrow seems to be the result of the work of the bees for the drainage of excess moisture rather than the utilization of pre-existing construction. No bee was found in this blind burrow during the excavation of the nests.

The worker bees are laborious but gentle. The drones are similar to the workers in the outer appearance but can easily be distinguished when alighting outside the nest due to their inclined or almost erect posture.



Fig. 11—Nest of *P. lendliana*, showing: brood combs, royal cells, membranous involucrum, region below brood area, pollen and honey pots, entrance burrow.

OBSERVATION ON *P. lendliana*

The four nests of *P. lendliana* (called ossongo in Kioko dialect) were found 1.5 to 2.5m below the soil surface. The nest opens to the exterior through an inclined and sinuous entrance burrow. The nest proper is round, slightly flattened above as well below, an average 20cm in horizontal diameter and 15cm in height. The nest walls are lined with propolis 0.4 to 1.0mm in thickness. As

in the species mentioned above, three areas are distinguished within the nest. The nest proper is 12cm in horizontal diameter and 7 to 8cm in height, when measured at outer surface of involucrum whereas it is 6cm in diameter and height at the inner surface of involucrum. The involucrum is made of 6 to 13 waxy sheets spaced at about 4mm intervals. The combs are horizontal, each 5 to 6cm in diameter, spaced 2mm and supported by thin columns of cerumen.

The mode of comb-building is similar to species which make spiral combs. In this species, however, the combs are super-

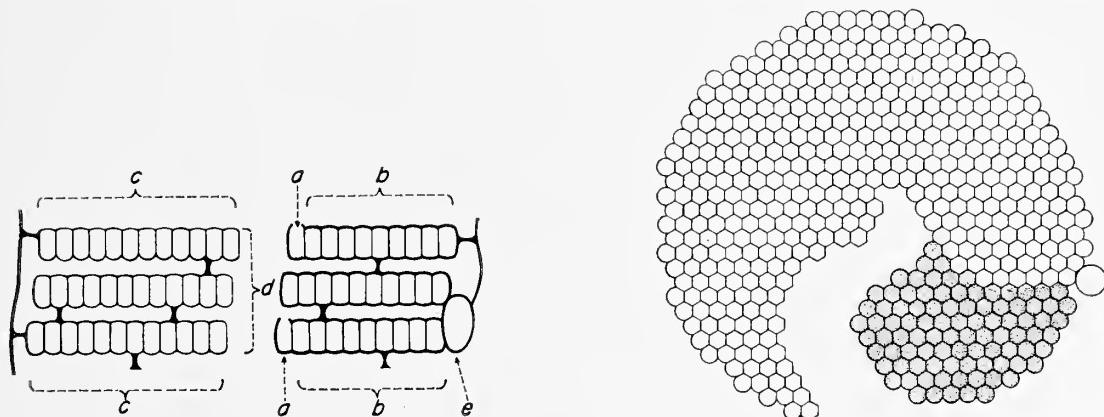


Fig. 12—Brood comb of *P. lendliana*, side view showing: a = cells in construction; b = cells with eggs or young larvae; c = cells with pupae or imago in which wax was removed; d = area with emerging bees; e = royal cell.

Fig. 13—Comb of *P. lendliana* seen from above. Construction front of new cells (dotted area) proceeds clockwise. Every comb has this design. At right a royal cell is seen.

imposed but independent of one another. Smith (1954) described a similar system in *Trigona denoitii* Vachal. The direction of the building front is, however, anticlockwise in his species while clockwise in *P. lendliana*. The building front of the combs follows the sector where bees are emerging (Fig. 12 and 13). Each cell is 4.5mm high by 2.0 to 2.3mm in diameter. Each comb contains about 600 cells. Royal cells are ovoid, about 7.5mm high 4.5mm wide.

The area of old cerumen layers has the same diameter as the brood area, situated immediately below the latter, receiving the entrance burrow at its upper part. This area consists of several irregular sheets made of hard but brittle cerumen, possessing numerous small cavities connected by canaliculi where bees are found. The garbage and resin deposits are found

at the bottom of this area. The resin stores are also found on the walls of the nests.

The area of pollen and honey pots surrounds the brood area except for its upper and lower parts. Each pot is usually spheric, averaging 2.5cm in diameter and height, though occasionally reaching 2cm wide and 4cm high. There is no difference in the localization of pollen and honey pots. Maximum honey storage seldom exceeds 1 liter. The honey is acid, somewhat sour, hence unpleasant.

The entrance burrow protrudes above the soil surface, forming a turret of 0.5 to 1.0cm in height. The transverse section of entrance burrow turret is in general round but was elliptical in one case. The diameter is about 8mm, but is constricted to 6mm at the uppermost part. The entrance is guarded by several bees at daytime but closed at night.

The drainage burrow was not always found. Usually the nests are built immediately above the sandy zone of 3 to 4cm, but in one case there was a drainage burrow and the general feature of its upper part was similar to that of *M. tanganyikae medionigra*.

The workers are gentle, not flying about when the nests are manipulated. The guards close the entrance with cerumen and resins rapidly, less than 30 seconds, when the nest is disturbed.

ADDITIONAL REMARKS

The colonies of the two species mentioned may be maintained in artificial hives. This is difficult however, because they lack adaptation to the marked oscillation of temperature and increased attack of enemies. In the subterranean nests of these species, a small inquilinous beetle, *Aecthina* sp., is found in the cerumen sheets below the brood area, which do no marked damage to the nest under normal conditions. But, in weak colonies introduced to the artificial hives, this beetle may increase and aggregate on and in the pollen pots. In this case, the hive can be damaged by *Aecthina* larvae within a few days.

M. tanganyikae medionigra usually begin a kind of absconding swarm if forced to live in the artificial hive. The workers transport wax, pollen and honey, the males stay outside the nest alighting less than 1m from the entrance. Within a few weeks

all bees disappear from the nest, leaving the mother queen alone. At this time, pillage to the abandoned nest may be performed by the same species.

Both species make use of old fungi-chambers of termite nests, especially those chambers distant from the center of the nests. My observations on the entrance burrow suggest that *M. tanganikae medionigra*, builds its own entrance burrow while *P. lendliana* seems to use the pre-existing tunnel of termites which is adapted as the entrance burrow. It was not ascertained whether or not termite nests were made by the same species.

ACKNOWLEDGMENTS

I would like to express my sincere thanks to Prof. Warwick E. Kerr for his suggestions in preparing this paper; further to Prof. J. S. Moure and Dr. O. L. Cartwright for the identification of the stingless bees and the parasitic beetle respectively, and to Dr. S. Sakagami for correcting the English translation.

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***NOMADOPSIS EUPHORBIAE* (Cockerell) SYNONY-
MIZED WITH *N. HELIANTHI* (Swenk and
Cockerell) (HYMENOPTERA: ANDRENIDAE)**

JEROME G. ROZEN, JR.¹

RECEIVED FOR PUBLICATION Nov. 20, 1962

ABSTRACT

Nomadopsis (Micronomadopsis) euphorbiae (Cockerell, 1925) is a junior synonym of *N. (Micronomadopsis) helianthi* (Swenk and Cockerell, 1907).

The following synonymy in the genus *Nomadopsis* is reported at this time so that I may use the correct name in a forthcoming revision of the parasitic bee genus *Oreopasites*. *Nomadopsis (Micronomadopsis) euphorbiae* (Cockerell, 1925) is a junior synonym of *N. (Micronomadopsis) helianthi* (Swenk and Cockerell, 1907).

At the time I revised the genus (Rozen, 1958) I regarded these two supposed species as exceedingly similar. The type of *helianthi*, a unique female, agreed with specimens of the well-known *euphorbiae* in every important respect except for possessing brighter yellow markings. Because of this difference and because the type of *helianthi* had been collected at War Bonnet Canyon, Sioux County, Nebraska, a locality far removed from the known range of *euphorbiae* (Rozen, 1958, map 13), I decided to consider them separate species until males from Nebraska could be collected. In the summer of 1962 I visited Sioux County, Nebraska, and collected a series of males and females at 7 miles north of Harrison. Although *Helianthus* was blooming profusely along the road, females gathered pollen only from *Euphorbia missurica* Raf. which grew in the field next to the road. The bees nested in barren areas among the sunflowers, where numerous *Oreopasites* were also found.

There are no differences in the external appearance between the males collected from Nebraska and typical *euphorbiae* males from southern Arizona, and their genitalia are virtually identical. Females from Nebraska tend to have light markings on

¹ Chairman and Associate Curator, Department of Entomology, The American Museum of Natural History, New York. Research for this paper was supported by the National Science Foundation (Grant G-14854).

the face slightly yellower than females from Arizona, but the only consistent difference is the white notal hairs of the Nebraska specimens compared with the faintly amberish hairs of the Arizona ones.

Nomadopsis helianthi, as now understood, is one of the most widely distributed species in the genus. Inhabiting arid regions, it ranges from the Great Central Valley of California to the southern tip of Baja California and eastward to western Nebraska.

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Rozen, Jerome G., Jr. 1958. Monographic study of the genus *Nomadopsis* Ashmead (Hymenoptera: Andrenidae). Univ. of California Pubs. in Ent., 15, pp. 1-202, 218 figs., 17 maps.

A NEW MOSS MITE FROM WESTERN U. S. (ACARINA: ORIBATEI, CEPHEIDAE).¹

TYLER A. WOOLLEY² AND HAROLD G. HIGGINS³

RECEIVED FOR PUBLICATION JULY 31, 1962

ABSTRACT

The genera of the family are listed and the synonymy of *Oribatodes* Banks 1895 is discussed briefly. *Sphodrocepheus tridactylus*, n. gen., n. sp., is described and figured. Distribution records of the species are indicated for Utah, California, Oregon and Washington.

Balogh (1961) characterizes the family Cepheidae Berlese 1896 as having six pairs of genital setae, a circular or oval hysterosoma and reticulate or rugose integument. He includes the following genera in the family:

- Microtegeus* Berlese, 1917.
- Ommatocepheus* Berlese, 1913.
- Eupterotegeus* Berlese, 1916.
- Tritegeus* Berlese, 1913.
- Oribatodes* Banks, 1895.
- Protocepheus* Jacot, 1928.
- Cepheus* C. L. Koch, 1836.
- Conoppia* Berlese, 1908.

¹ Research supported by National Science Foundation.

² Colorado State University, Fort Collins, Colorado.

³ NSF-RP-HST.

Banks (1895) describes the genus *Oribatodes* from five specimens taken at different times in rotten debris under loose bark of dead trees, at Sea Cliff, N. Y. He describes this new genus in part as follows: ". . . the tarsus with but one claw, the genital opening is large and just in front of the larger anal opening, not well separated from it. The roughened appearance of the only species known to me distinguishes it from its allies." In the same article he designates the type species as *O. mirabilis*, but makes no drawing of the new genus and species.

Ewing (1917) in his key to the beetle mites designates *Oribatodes* with monodactyle tarsal claws and smooth integument. No drawing accompanies the key and no mention is made of the genital and anal openings.

Berlese (1910) describes a monodactyle species from Washington, D.C., as *Tegeocranus longisetus*, and illustrates by a dorsal figure his new species. This figure shows the species with a roughened integument and 11 pairs of seta on the hysterosoma.

Banks (1906) describes *Cepheus lamellatus* from a single specimen taken at Blue Hill, Massachusetts. This species has 10 pairs of dorsal setae, is roughly reticulate; the genital aperture is less than one-half its length in front of the much larger anal opening. Jacot (1928) places both *Cepheus lamellatus* Banks, and *Tegeocranus longisetus* Berlese in *Cepheus (Oribatodes) mirabilis* (Banks), 1895. Although Banks' *C. lamellatus* and Berlese's *T. longisetus* are both figured in the original drawings as possessing long hairs on the hysterosoma, these species appear to differ in that the lamellae are joined in *T. longisetus*, but distinctly separate in *C. lamellatus*.

Balogh (1961) apparently follows Jacot (1928) in this synonymy and figures Berlese's species as *Oribatodes mirabilis* Banks.

Collecting in the western part of the United States has uncovered a large cepheid mite which superficially resembled *O. mirabilis*, but which differs from this species in its three tarsal claws, widely separated anal and genital openings and a rather smooth integument. These and other differences are so pronounced that the writers consider this to be a new genus and a new species. The diagnoses and descriptions follow.

Sphodrocepeus, gen. nov.

Named from the Greek, *sphodros*, strong, because of its strongly sclero-

tized tectopedia, which differ from other cepheids, and the sclerotizations of the apodematal structure beneath the setae on the dorsum of the notogaster and the ventral apodematal arrangement.

Diagnosis: Lamellae broad, marginal, projected over and completely covering rostrum; rostrum sharply pointed, rostral hairs subterminal; interlamellar hairs as long as lamellae; pseudostigmata inserted in bases of lamellae; hysterosoma with a circular, internal, sclerotized apodeme connecting the setal bases of dorsal setae beneath integument; camerostome with a prominent, hinged mentum, posteriorly articulated with large condyles, chelicerae small, robust; tectopedia I and II prominent, heavily sclerotized, projected laterally; tectopedia III and IV large, transverse, sclerotized ridges posterior to acetabulae of legs III, IV; heterotridactylous; genital and anal openings widely separated.

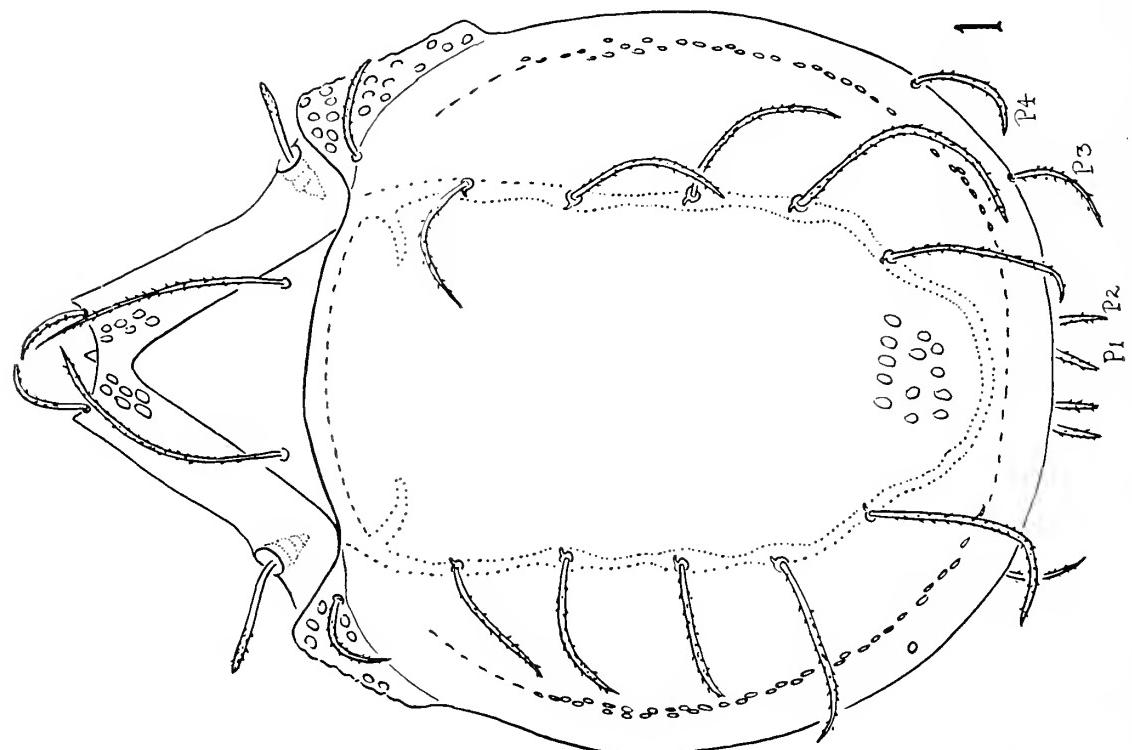
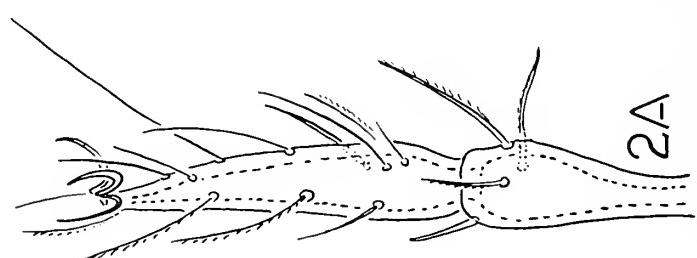
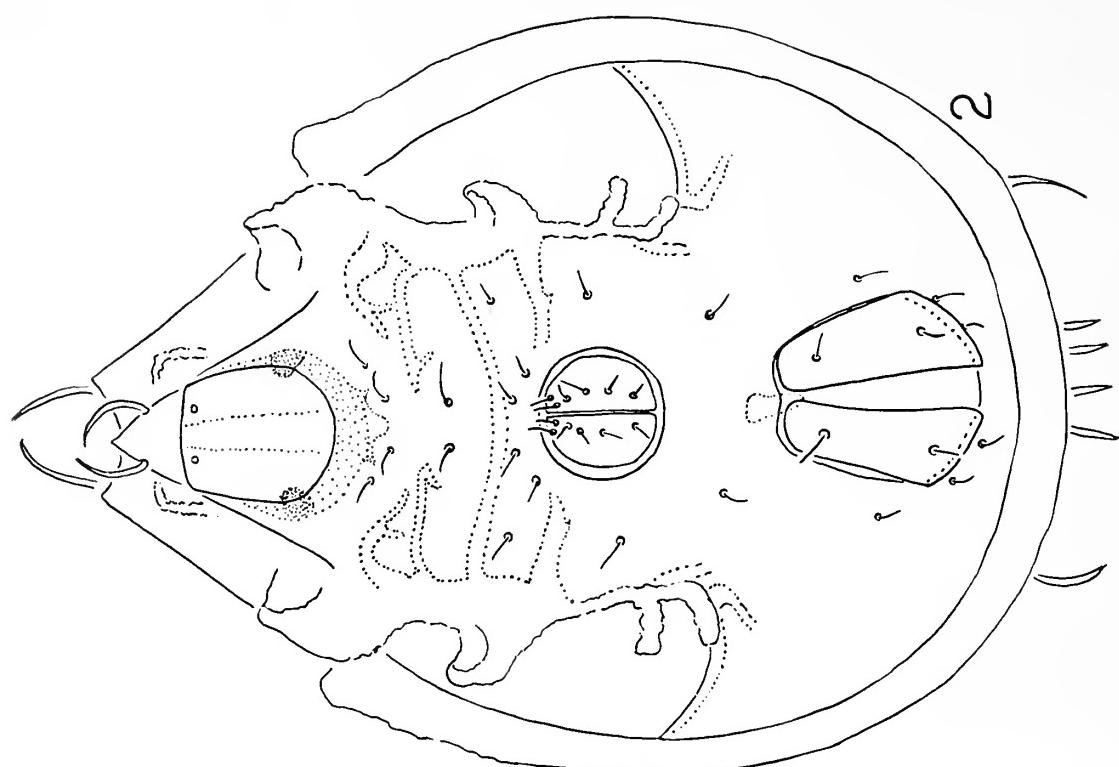
Sphodrocepheus tridactylus, n. sp.

(Figs. 1, 2)

Description: Reddish-brown, mahogany color; propodosoma broadly triangular, one-fourth as long as hysterosoma; rostrum not visible from above, covered by lamellae, except for sharply pointed tip, rostral hairs finely serrate, one-third as long as lamellar hairs, inserted subterminally at lateral margins of rostrum, projected anteriorly beyond translamella, only partly visible from above; lamellae wide, flattened plates, projected anteriorly over rostrum, coalesced medially with translamella to form a broad, indented anterior margin, surrounding pseudostigmata at bases, surface sculptured; lamellar hairs as long as width of anterior margin of coalesced lamellae, finely pectinate, decurved, inserted in anterior margin medial to lateral point of lamella; interlamellar hairs as long as lamellae, decurved, finely pectinate, extended anteriorly beyond margin of translamella, inserted at level of pseudostigmata twice the width of insertion areola from medial margins of lamellae; pseudostigmata vase-shaped, aperture circular and three times as wide as diameter of pedicel of pseudostigmatic organ; pseudostigmatic organ about as long as lamellar hairs, narrowly clavate.

Hysterosoma nearly circular, anterior margin of dorsosejugal suture roundly curved medially, incised slightly posterior to lamellae; roughly sculptured, squarish shoulders at antero-lateral margins, each shoulder with a long, curved, pectinate seta at level of dorsosejugal suture; five pairs of long, pectinate, dorsal setae arranged in a slightly curved, longitudinal row midway between lateral margin and median area of dorsum of notogaster, each insertion with a tiny curved, internal spur, the entire setal row demarcated beneath integument by a linear, sclerotized apodematal structure connecting all setal insertions in the row and coalesced anteriorly on each side with lateral ends of the sclerotized bar of dorsosejugal suture; pairs of bristles P: 1 and P: 2 at posterior margin, shorter than other setae; P: 3 and P: 4 half as long as dorsal setae, inserted near postero-lateral margin; areae porosae numerous, near lateral margins of notogaster in linear arrangement; sculpturing as in figure 1.

Camerostome attenuated anteriorly, drop-shaped, basal two-thirds with a



strongly sclerotized mentum articulated at postero-lateral corners with two prominent internal, heavily sclerotized condyles; chelicerae small, with incisive digits (Fig. 2); tectopedia I large, rugose, as long as width of camerostome, tectopedia II a third as large as tectopedia I, sculptured like tectopedia I; tectopedia III and IV prominent, sclerotized bars adjacent to coxæ acetabulae, tectopedia IV continuous with sclerotized curved transverse bar that extends to lateral margin of ventral plate; apodemata and setal arrangement as seen in figure 2, apodemata I doubly curved, apodemata II a sclerotized, transverse bar anterior to genital aperture, apodemata III extended nearly to genital aperture at medial tip, apodemata IV coalesced with sclerotized structure of tectopedia IV; genital aperture circular, situated its diameter anterior to anal aperture, each genital cover with six setae, g: 1 and g: 2 in antero-medial corner of cover, g: 3 closer to g: 2 than to g: 4; g: 5, g: 6 subequally spaced posteriorly, closer to medial margin of cover than to lateral, setae simple, subequal in length; aggenital setae midway between genital and anal aperture as seen in figure 2; anal aperture trapezoidal, longer than broad, nearly twice as large as genital opening, anal covers long, each with two setae; adanal setae inserted close to anal aperture, ada: 1 and ada: 2 posterior to opening, ada: 3 lateral to aperture and midway between ends of covers.

All legs heterotridactylous as seen in figure 2A.

Length 720 μ , hysterosoma 570 μ ; width 570 μ .

One holotype specimen and 12 paratypes were collected at Mirror Lake, Wasatch County, Utah, 31 August 1948 by S. and D. Mulaik. Additional specimens collected are as follows:

CALIFORNIA 3 specimens from leaves under trees at Patrick's Point State Park, 25 August 1956, by H. and M. Higgins.

UTAH 1 specimen from Diamond Fork Canyon, 17 June 1956 by H. Higgins; 2 specimens from Spruces Recreational Area, Salt Lake County, 24 July 1957 by H. Higgins; 3 specimens from moss, Spruces Recreational Area, Salt Lake County, 13 June 1956 by H. Higgins; 2 specimens from Soapstone, Wasatch County, 4 September 1955 by H. and M. Higgins; 1 specimen from Lost Lake, Wasatch County, 5 September 1955 by H. and M. Higgins; and 1 specimen from Oak City, Millard County, 18 April 1954, by F. Higgins.

WASHINGTON 1 specimen from Chehalis, 19 May 1956 by M. Higgins; 2 specimens from moss, Neah Bay, 23 August 1956, by H. Higgins.

OREGON 2 specimens from Meeker, 19 August 1956 by H. and M. Higgins; 3 specimens from moss on trees, Cottage Grove, 24 August 1956 by H. and M. Higgins.

Figure 1. Dorsal view of *Sphodrocepehus tridactylus*, n. gen., n. sp., legs omitted.

Figure 2. Ventral view of *Sphodrocepehus tridactylus*, n. gen., n. sp., legs omitted.

Figure 2A. Dorso-lateral view of tibia and tarsus I.

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**DIURNAL AND NOCTURNAL LEPIDOPTERA OF
BAY RIDGE WATERFRONT**

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Abstract

A six year survey of a portion of the Brooklyn, waterfront traversed by the Belt Parkway, describes the topography, vegetation, and the lepidoptera netted or observed. Six families, 18 genera, and 27 species of butterflies; and 11 families, 40 genera, and 48 species of moths are reported together with field information. It is concluded that in spite of the cultivation of former waste land, and the encroachment of buildings, leaving little ground for wild vegetation, the lepidoptera persist as long as the respective food plants for their larvae have a chance of survival however precarious.

The area under consideration extends from 69th Street to the Narrows at Fort Hamilton in Brooklyn, New York. This winding stretch of shore line is about two and one half miles long, free of any docking facilities, and traversed by the New York Belt Parkway. Its direction runs true north to south, bordered on the west by the waters of New York Bay, and on the east by Shore Road, with an iron picket fence separating the region in its entire length from Shore Road with apartment houses and smaller dwellings at its eastern side.

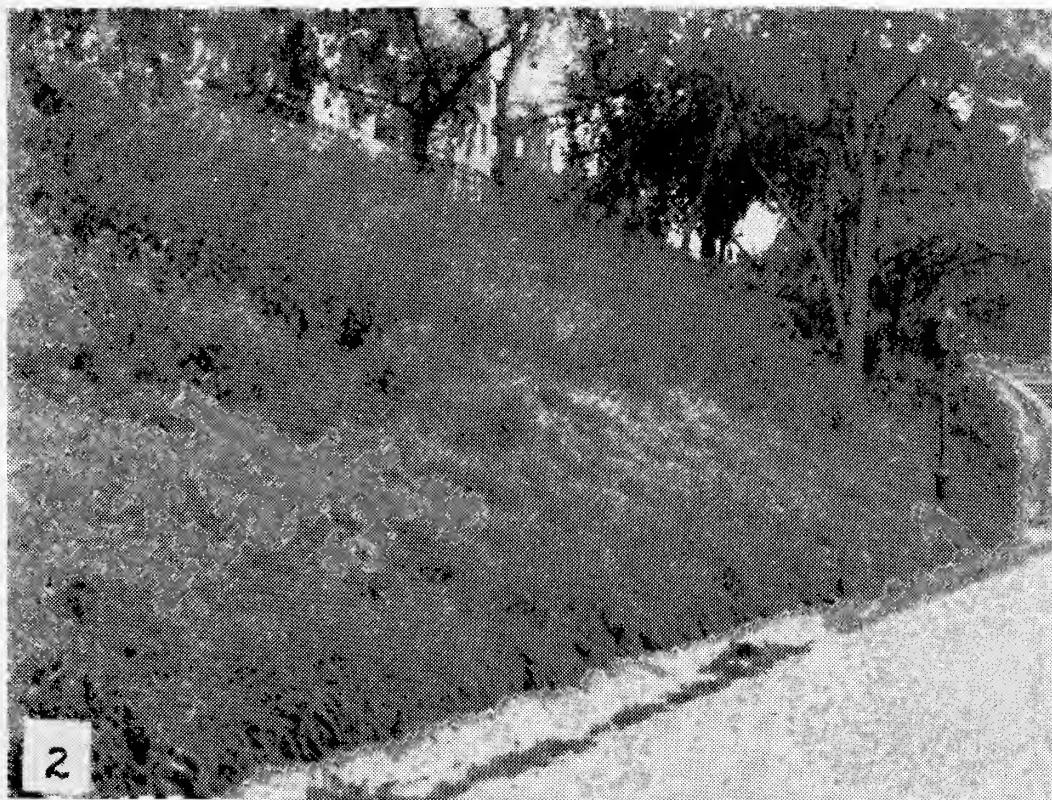
The topography includes long expanses of grassy fields, gently inclined pathways, and sharply rising slopes fusing at the Narrows with the escarpments of Fort Hamilton which, at the present

time, have been pierced for the eastern anchorage of the new Verrazano-Narrows bridge to be erected at this site.



1

No. 1. View at 95th Street and Shore Road, looking south, and showing the abundancy of brush growth on the steeply rising slope.



2

No. 2. View at 90th Street, looking south, showing pathway leading to Shore Road with a steep slope overgrown with abundant vegetation.

During the summer months the wild vegetation consists of patches of white, red, and bush clover, dandelion, knotweed, self-heal, chicory, wood sorrel, plantain, hawkweed, yarrow, Queen-Anne's-lace, burdock, thistles; clusters of bladder and white campion, milkweed, and giant ragweed. Towards the end of the summer the slopes and the ridges are covered with various species of wild asters, daisy fleabanes, honeysuckle, pink morning-glory, hedge-roses, and goldenrod.

Amongst the trees and shrubs are elms, poplars, willows, aspen, linden, black oaks, hawthorns, mulberries, maples, sycamores, locusts, ailanthus' beachplum, privet, and forsythia.



No. 3. View at 85th Street, looking south, showing pathway with slope rising gently towards Shore Road.

All photos were taken during the last days of September 1962.

The entire area has been under my systematic and careful observation for six years (1955 to 1961) except for the summer months of 1958 which were spent in Europe. In spite of the continuous south and north-bound auto traffic along the Belt Parkway, the nearness of the towering apartment houses at the east side of Shore Road, and the close proximity of the Bay Ridge business district centered at 86th Street and Third, Fourth, and

Fifth Avenues, diurnal and nocturnal lepidoptera have tenaciously clung to this region of roughly cultivated parkland at the edge of a sprawling metropolis.

Most specimens mentioned in the following annotated list, except those tagged "observed," have been netted by me and are preserved in my private collection. Six families, 18 genera, and 27 species of butterflies; 11 families, 40 genera, and 48 species of moths are represented. In reference to taxonomy I have followed Klots (1951), in the case of Rhopalocera, and Holland (1937), in respect to Heterocera; the nomenclature for the latter, however, has been revised according to modern usage by Dr. Frederick H. Rindge, Associate Curator of Entomology at the American Museum of Natural History, New York.

I thank both Dr. Klots and Dr. Rindge for checking the assembled list against possible errors, and for several identifications that could not have been made by myself. To Dr. Louis Marks of the Biology Department of Fordham University I am indebted for the reading of the manuscript in its entirety, for helpful suggestions, and for his constant encouragement.

RHOPALOCERA

PAPILIONOIDEA

Danaidae:

Danaus plexippus Linnaeus

August, September, October 1955, observed only;

August, September, October 1956, observed only;

2 ♀, Oct. 4, 1957; ♂, Oct. 17, 1959; ♂ & ♀, Oct. 10, 1960; ♂ & ♀, Aug. 20, 1961, in copula; 2 ♂ & 2 ♀, Oct. 15, 1961, perfect specimens.

Throughout the six-year period Monarchs were observed in great numbers during the latter part of October, visiting wild asters and alighting frequently on pod-bearing milkweed along the slopes. Concentrations of these butterflies were seen one day, only to be gone the next. This leads to the conclusion that this particular region is still being used as a flyway to the south for these migratory danaidae.

Nymphalidae:

Phyciodes tharos Drury

♂ & ♀, July 16, 1959; ♂ & ♀, Aug. 7, 1959; ♂ & ♀, Sept. 5, 1960, in copula; ♂ & ♀, Sept. 18, 1961, frequent.

Polygonia comma Harris

♂, July 29, 1956; ♂ & ♀, July 30, 1961.

Polygonia interrogationis Fabricius

δ & φ , July 30, 1956; δ & φ , Aug. 20, 1959; 2 δ & φ , June 17, 1960; many more specimens were observed that day at sundown flying high about elm trees and privet bushes.

Nymphalis antiopa Linnaeus

φ , July 9, 1961. The only specimen ever seen or caught in this region.

Vanessa atalanta Linnaeus

δ & φ , June 15, 1957; 2 φ , June 25, 1959, small form; δ & φ , July 17, 1959; φ , Oct. 12, 1959, large form.

Vanessa cardui Linnaeus

φ , Sept. 28, 1957. No other specimens were ever observed or caught.

Vanessa virginiensis Drury

δ & φ , Sept. 5, 1959; δ & φ , Oct. 6, 1959; φ , Oct. 12, 1960; δ & φ , Oct. 15, 1961, frequent.

Precis lavinia Cramer

φ , Oct. 3, 1959; δ , Oct. 4, 1959; φ , Oct. 6, 1959.

Lycaenidae:

Strymon titus Fabricius

φ , July 15, 1960; δ & φ , July 20, 1961.

Strymon melinus Huebner

δ & φ , July 16, 1959; δ & φ , Aug. 7, 1959; δ & φ , Aug. 20, 1960. Frequent in the playing fields and on the slopes.

Strymon falacer Godart

δ & φ , June 21, 1957.

Everes comyntas Godart

3 δ & 2 φ , Sept. 26, 1959; δ & φ , Oct. 6, 1959; 2 δ & 2 φ , Aug. 29, 1960; δ & φ , July 4, 1961, in copula.

Abundant in the meadows, play grounds, and on the slopes; observed throughout the entire period.

Lycaeopsis argiolos pseudargiolos Linnaeus

δ & φ , July 6, 1955; φ , June 11, 1959; 2 δ & φ , June 18, 1960, observed many other specimens that day flying high about locust trees. All specimens listed are summer forms.

Papilionidae:

Papilio polyxenes asterius Stoll

δ & φ , July 17, 1959; δ & φ , Aug. 7, 1959; δ & φ , May 30, 1960; δ & 2 φ , July 30, 1961; δ & φ , Aug. 1961, in copula.

This rather tame swallowtail was observed in frequent numbers, almost abundantly, throughout the entire period. Several females were caught by hand and liberated again.

Papilio glaucus Linnaeus

δ , July 26, 1959, large, pale yellow form; δ , June 17, 1960, small, pale yellow form; φ , July 1, 1961, small ochrous yellow variation.

Several other specimens were observed in 1960 and 1961, flying high about elms, poplars, and locust trees.

Pieridae:

Colias eurytheme Boisduval

♂ & ♀, July 6, 1955; ♂ & ♀, Aug. 16, 1956; 2 ♂ & 3 ♀, Sept. 3, 1957; ♂ & ♀, Oct. 4, 1959; ♂ & ♀, Aug. 20, 1960; 2 ♂ & 2 ♀, Oct. 10, 1961; ♀, Aug. 7, 1959, white form; ♀ Sept. 6, 1959, white form.

The orange female form of these Sulphurs was in abundance throughout the entire period. This is the most common of all the butterflies in this region. Single specimens were observed as early as April 28th, and as late as November 15th. Some of the males show partial hybridization with *Colias philodice*.

Colias philodice Latreille

♀, Sept. 28, 1957; ♂ & ♀, Oct. 4, 1959; ♂ & ♀, Oct. 8, 1960; 2 ♂ & ♀, Sept. 30, 1961, frequent; ♂, Oct. 10, 1960, narrow bordered, colder weather form.

Eurema lisa Boisduval & Leconte

♀, Sept. 5, 1959; ♀, Sept. 19, 1959, very small and pale yellow; ♂, Oct. 12, 1959.

Pieris rapae Linnaeus

♂ & ♀, July 1956; ♂ & ♀, July 13, 1957; ♀, Oct. 4, 1957, a very small specimen; 2 ♂ & ♀, Sept. 26, 1959; ♂ & ♀, Oct. 12, 1960; ♂ & ♀, Aug. 15, 1961, in copula.

This species occurs in great numbers from early spring until the late fall.

Pieris protodice Boisduval & Leconte

♀, Oct. 4, 1957, a very dark checkered specimen; ♂ & ♀, June 11, 1960; ♂ & ♀, July 20, 1960.

HESPERIOIDEA

Hesperiidae:

Epargyreus clarus Cramer

♂, June 26, 1960; ♀, July 16, 1961; ♀, July 18, 1961.

Pholisora catullus Fabricius

♂, July 16, 1959; ♂ & ♀, July 17, 1959; ♂ & ♀, July 15, 1960; ♂ & ♀, Aug. 3, 1961. Quite frequent along the pathways and roadsides. Observed throughout the entire period.

Hylephila phyleus Drury

♂, Oct. 6, 1959; ♂, Oct. 8, 1959; ♀, June 15, 1959.

Poanes zabulon Boisduval & Leconte

3 ♂, June 17, 1960; 2 ♂ & 2 ♀, June 8, 1961.

Poanes hobomok Harris

2 ♂, June 15, 1959; ♂, June 17, 1960.

Panoquina ocola Edwards

♀, Oct. 6, 1959; ♀, Oct. 17, 1959.

The last four species occur infrequently and sporadically along the slopes of this region.

HETEROCERA

Sphingidae:

Phlegetonthius sexta Johanssen

♂, July 5, 1955; ♀, July 7, 1956; ♂, July 8, 1959.

Atreides plebeja Fabricius

♂, July 12, 1961.

Sphinx chersis Huebner

♀, July 17, 1956; ♂, July 18, 1956; ♂, July 19, 1956; ♀, July 6, 1959;
♂, July 9, 1959.

Pholus satellitia pandorus Huebner

♂, July 18, 1956.

Pholus achemon Drury

♂, July 19, 1956; ♀, July 13, 1957.

All sphingidae have been caught on the wing hovering over bladder-campion at dusk between 7:00 and 10:00 p.m. Since their larvae's favorite food plants: potato, tomato, and grapevine, are still plentiful on Staten Island, a mile and a half across New York Bay, these hawkmoths must be considered roving visitors from that region.

Saturniidae:

Samia cynthia advena Watson

♂, May 28, 1957; caught on the wing at dusk.

Eight cocoons were found Jan. 15, 1955. 3 ♂ & 5 ♀ emerged May 1 to 17, 1955. Four cocoons were obtained Nov. 2, 1959; ♀ emerged Jan. 14, 1961, ♀ emerged May 27, 1961, 2 ♂ emerged May 15, 1961. These cocoons were exposed to a cold temperature of 13° to 15° F. in a home refrigerator from Aug. 27 to Dec. 12, 1960.

Hyalophora cecropia Linnaeus

♂ & 2 ♀, July 12, 1955. They were found newly emerged on the picket fence. None were encountered ever since.

Antheraea polyphemus Cramer

♀, July 1, 1955, much damaged and worn out.

♂, June 27, 1957, a perfect specimen.

On Aug. 24, 1959, a fully grown larva was found on a maple trunk, it spun its cocoon the same day, ♂ adult emerged April 17, 1960.

Ctenuchidae:

Scepsis fulvicollis Huebner

♂, Sept. 3, 1956; ♀, Aug. 25, 1960; ♀, July 20, 1961.

The last two specimens were caught in the late afternoon on goldenrod.

Arctiidae:

Halisidota tessellaris J. E. Smith

♂, June 29, 1955; ♀, June 27, 1957; ♂, June 15, 1960.

Diacrisia virginica Fabricius

♀, July 29, 1956; ♀, Sept. 3, 1956.

Hyphantria cunea Drury

♂ & ♀, June 28, 1957; ♂ & ♀, July 15, 1957.

Noctuidae:

Acronicta americana Harris

♂, Aug. 24, 1955; ♂, June 11, 1957; ♀, July 10, 1959; ♀, June 17, 1960;
♀, July 1, 1961.

Acronicta lobeliae Guenée

♂, Aug. 16, 1959

Orthodes vecors Guenée

♀, Oct. 29, 1960.

Hyppa xylinoides Guenée

♂, Apr. 22, 1960.

Amphipyra pyramidoides Guenée

♂, Aug. 6, 1961; ♂ & ♀, Aug. 10, 1961.

Prodenia ornithogalli Guenée

♀, Oct. 23, 1959.

Graphiphora e-nigrum Linnaeus

♀, Aug. 24, 1959.

Pseudaletia unipuncta Haworth

♂, July 10, 1956; 2 ♀, Aug. 3, 1959; ♂ & ♀, Sept. 4, 1960; ♂ & ♀, Sept. 15, 1961. Abundant during August and September throughout the entire period.

Lithophane laticinerea Grote

♀, Nov. 9, 1960.

Lithophane lamda thaxteri Grote

♂ & ♀, Oct. 8, 1960.

Enargia infumata Grote

♂ & ♀, July 2, 1955; ♂ & ♀, July 3, 1955; 2 ♂, Oct. 13, 1957.

Pyreferra hesperidago Guenée

♀, Oct. 1, 1960.

Heliothis zea Boddie

♂ & 2 ♀, Sept. 26, 1959, netted during day time in high, dry grass.

Autographa biloba Stephens

♀, July 8, 1957.

Autographa precationis Guenée

♂, June 29, 1955; 2 ♂, July 12, 1956; ♂ & ♀, Aug. 3, 1957; ♀, Aug. 12, 1959; ♂ & ♀, July 5, 1960; ♂ & ♀, Aug. 8, 1961.

This species flies during the day time visiting various flowers, mostly white clover. Abundant throughout the entire period.

Autographa bimaculata Stephens

♂, July 3, 1960.

Anagrapha falcifera Kirby

♂, Aug. 28, 1960.

Caenurgina erechtea Cramer

♂, July 30, 1959; ♀, Oct. 23, 1959; 2 ♀, Oct. 30, 1960; ♂, Aug. 15, 1961.

Catocala dejecta Strecker

♀, Aug. 12, 1961, caught at rest on picket fence.

Catocala amatrix Huebner

♂, Sept. 15, 1956; ♀, Sept. 22, 1956; ♀, Sept. 19, 1957.

All three specimens were caught at rest on poplar trunks.

Catocala unijuga Walker

♀, Sept. 9, 1956, caught at rest on maple trunk.

Catocala ilia Cramer

♀, July 1, 1959.

Zale lunata Drury

♂, June 29, 1955; ♂ & ♀, Aug. 15, 1957.

Epizeuxis americanalis Guenée

♀, Oct. 3, 1960.

Lasiocampidae:

Malacosoma americana Fabricius

♂ & ♀, June 15, 1957; ♂ & ♀, June 6, 1960; 2 ♂ & 2 ♀, June 8, 1960. These moths were taken in the day time from the picket fence and from various tree trunks. At night an invasion of hundreds of specimens occurred in the near-by business district flocking to neon signs and lighted show windows. The invasion lasted from June 6 to June 10, 1957. A full scale repetition of this occurrence took place from June 8 to June 11, 1960, a minor one from June 5 to June 10, 1961.

Geometridae:

Alsophila pometaria Harris

3 ♂, Nov. 11, 1959; 2 ♂, Nov. 15, 1960, 4 ♂, Nov. 17, 1960; 5 ♂, Nov. 11, 1961. Obtained from various tree trunks, picket fence, and house walls. From Nov. 8 to 17, 1960, and Nov. 9 to 14, 1961 large numbers of these male *pometaria* were observed on show windows in the business district during day time. Wingless females were never obtained nor observed.

Physostegania pustularia Guenée

♂, July 3, 1961; ♀, July 5, 1961.

Caripeta divisata Walker

♂, Aug. 5, 1961; ♀ Aug. 8, 1961.

Haematopis grataria Fabricius

♂ & ♀, July 16, 1959; 2 ♂ & 2 ♀, July 25, 1960.

In abundance, flying at dusk in high grass; observed large numbers throughout July 1961.

Psychidae:

Thyridoperyx ephemeraeformis Haworth

Winged males were never caught in the open. "Bags" with wingless and legless females were obtained during the latter part of August, and the first two weeks in September during the entire period. Some females were found entirely free of their pupal shells, others were still partially or wholly enveloped by their pupal cases with merely a slit-like opening at the anterior end. Abundant on young locust and hawthorn trees.

Aegeriidae:

Sylvora acerni Clements

♂, July 15, 1956; ♀, June 20, 1957; ♀, July 1, 1959.

All specimens were obtained during day time resting on flowers.

Pyralidae:

Eustixia pupula Huebner

♂ & ♀, July 3, 1960; ♂ & ♀, June 30, 1961.

These miero-moths were found resting on tree trunks, benches, and the picket fence. At night they flocked to the lighted show windows of the business district in large numbers.

Pediasia trisecta Walker

♂ & ♀, July 6, 1960; ♂ & ♀, June 30, 1961.

Agriphila vulgivagellus Clemens

♂, July 3, 1960; 2 ♂ & 2 ♀, June 30, 1961.

Archips argyrospila Walker

♂ & ♀, June 28, 1959; ♂ & ♀, June 23, 1960; 2 ♂ & 2 ♀, June 30, 1961.

On this date an unusually strong invasion of large numbers was observed in the business district, covering neon signs and lighted show windows.

Pterophoriae:

Oidaematophorus monodactylus Linnaeus

2 ♂ July 7, 1961; ♀, July 10, 1961. All specimens were caught during day time resting on blades of grass.

All species of moths, not designated differently, were obtained by chance near or under the park and street lights which dimly illuminate this section at night.

Conclusion

The list of rhopalocera from this region may be fairly complete. For the list of heterocera, obviously, completeness cannot be claimed since new species may show up at any time. However, my survey purports to give a representative count of the lepidoptera one may encounter in this fringe territory. It is surprising to know that in spite of a certain cultivation of former waste lands, and the encroachment of building constructions which leave very little ground for wild vegetation, a hardy breed of lepidoptera will persist as long as the respective food plants for their larvae have a chance of survival.

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**THE ANATOMY OF THE ADULT QUEEN AND
WORKERS OF THE ARMY ANTS *ECITON*
BURCHELLI WESTWOOD AND *ECITON*
HAMATUM FABRICUS**

Roy M. WHELDEN

[CONTINUED]

THE REPRODUCTIVE SYSTEM

The reproductive system of *Eciton* is of interest, because of the queen's capacity for mass production of eggs, and also because of the significance the regular broods have for cyclic functions in the colonies (Schneirla, 1938, 1944, et seq.)

It is relevant to mention the regular variation in colony function and the condition of the colony queen as reported by Schneirla (1938, 1949, 1957) of *Eciton* under natural conditions. Schneirla's extensive studies have shown that the activities of both *Eciton hamatum* and *burchelli* present "a striking regularity in all of their principal colony operations, clearly related in its evolutionary background to the physical conditions of surface life. . . . Colony functions in these two species . . . center around two well-marked repetitive activity phases. . . . One of these is the nomadic phase, a period averaging 17 days in *E. hamatum* and 13 days in *burchelli* colonies; during this phase, the colony carries on extensive daily raids, followed by an emigration at the day's end. The other is the statary phase, a period of relative quiescence, during which raids are much smaller or occasionally absent, and the colony stationary in some sheltered place. The statary phase averages about 20 days in *E. hamatum* and 21 days in *burchelli*. During the nomadic phase, the brood comprises developing larvae, while in the statary phase, pupal development occurs, and also, during the last half, egg-laying and larval development of a new brood." In scores of colonies of *Eciton hamatum* and *burchelli*, and in numerous colonies of other species of this genus, the queens were always found contracted in the nomadic phase, entering physogastry near the end of this phase, progressing to maximal physogastry during the first week of the statary phase, and delivering the eggs of a new brood during the intermediate part of the statary phase (Schneirla, 1947).

Beginning at the posterior entrance and proceeding forward, the genital entrance may be observed as a long shallow space, bounded below by a thick membrane extending from the sclerotized wall of the 5th gastric segment to its anterior margin. Here it turns abruptly upward to form the bursa copulatrix a transversely elongate pouch, with a thick wall characterized by many unequal deep irregular folds, extending from one side of the pouch to the other. On the posterior-dorsal side, this wall joins the thin walls of the greatly modified 6th and 7th gastric segments lying alongside and above the sting. The size of this depends upon the extent of the folding of the walls, which sometimes leaves scarcely any free space within. In other individuals, the cavity is of some size and usually empty. No sperm mass was found therein but there were a few eggs in each of two queens, near the end of an egg-laying period. One queen taken in coitus (1946 H-L,—Schneirla, 1949) showed scarcely any folding of the pouch wall. This pouch is merely an adaptation to receive the posterior end of the large abdomen of the male; and has no other function. The surface of the ventral wall of the genital entrance is armed with many transverse rows of coarse spines from 10–50 μ long (Fig. 9, L, M). On the membrane forming the dorsal surface, spines are limited to small areas, mostly near the anterior part of this surface. There the spines, in transverse rows like those of the ventral surface, are smaller, slender, and with finely pointed apices. No spines occur on any part of the walls of the pocket.

The only opening into the genital entrance (except the large mouth of the bursa) is the vagina in the center of the anterior wall of the genital entrance. The vaginal opening is large and transversely elongate, the margins normally rather closely adpressed, except during the prolonged period of laying when the opening becomes enlarged and nearly circular.

The vagina is a thick-walled organ of variable dimensions. In some individuals, it is long, and of small diameter; in others, it is short but greater in diameter. These dimensions are not always correlated with the periodic changes in the reproductive system. For example, of two laying queens in fully physogastric condition, one has the diameter large with the vagina long and narrow; the other has the diameter small with the vagina scarcely half as long. In both queens a row of several eggs occurs in the lumen of the vagina.

The wall of the vagina is thick and has four distinct layers. The innermost is a thick homogeneous membrane, bearing slender, flexible setae on its inner surface. Surrounding this intima, is a layer of long uninucleate columnar cells comparable to the elongate hypodermal cells noted earlier. Outside this layer, are two layers of muscle fibres; the inner, of longitudinal fibres, is thin; the outer, of circular fibres, thicker. Enclosing these tissues, is a thin, scarcely discernable membrane. Near the end of an egg-laying period, eggs may be seen in the lumen of the vagina, sometimes only one or two, occasionally as many as six.

Anteriorly, the vagina joins the median oviduct. Usually, the union forms a straight tube with no distinction at the point of union; but individuals are found in which a sharp bend or even a S-shaped curve occurs where the oviduct joins the vagina.

The median oviduct and the paired oviducts extending upwards from the anterior end of the median oviduct are similar in structure, being formed of three distinct layers. In contracted queens, the two inner layers are forced into deep closely adpressed folds, the entire wall measuring 50–65 μ in thickness (Fig. 12, E). The innermost layer is a membrane having an average thickness of 1–3 μ . In *hamatum* queens, on the inner surface of this membrane, towards the lumen, a few irregularly spaced acute spines about 2 μ long (Fig. 12, I) occur. These spines, directed posteriorly, do not seem to be pressed against the surface of the membrane on which they occur. In all contracted queens, the lumen of the oviduct is practically eliminated, so compactly is the wall adpressed. The greater part of the wall of the oviduct is formed of a layer of elongate cells having ellipsoidal nuclei, 4–6 μ long and 1.4–3 μ in maximum diameter. In contracted queens, they appear as radiating groups in each of the large folds of the wall (Fig. 12, I); in physogastric queens, the wall becomes progressively thinner as swelling of the gaster progresses and the longitudinal muscles gradually become a sparse layer of fibres. The irregularly radiate cells of the middle layer are gradually pressed out until they are encircling muscle fibres; a few cells having nuclei much larger than the others occurring here (Fig. 12, G). The inner membrane becomes thin with the minute spines then lying closer to its surface. In *burchelli* queens, these spines become slightly thickened areas in an otherwise smooth wall. In contracted queens and those in

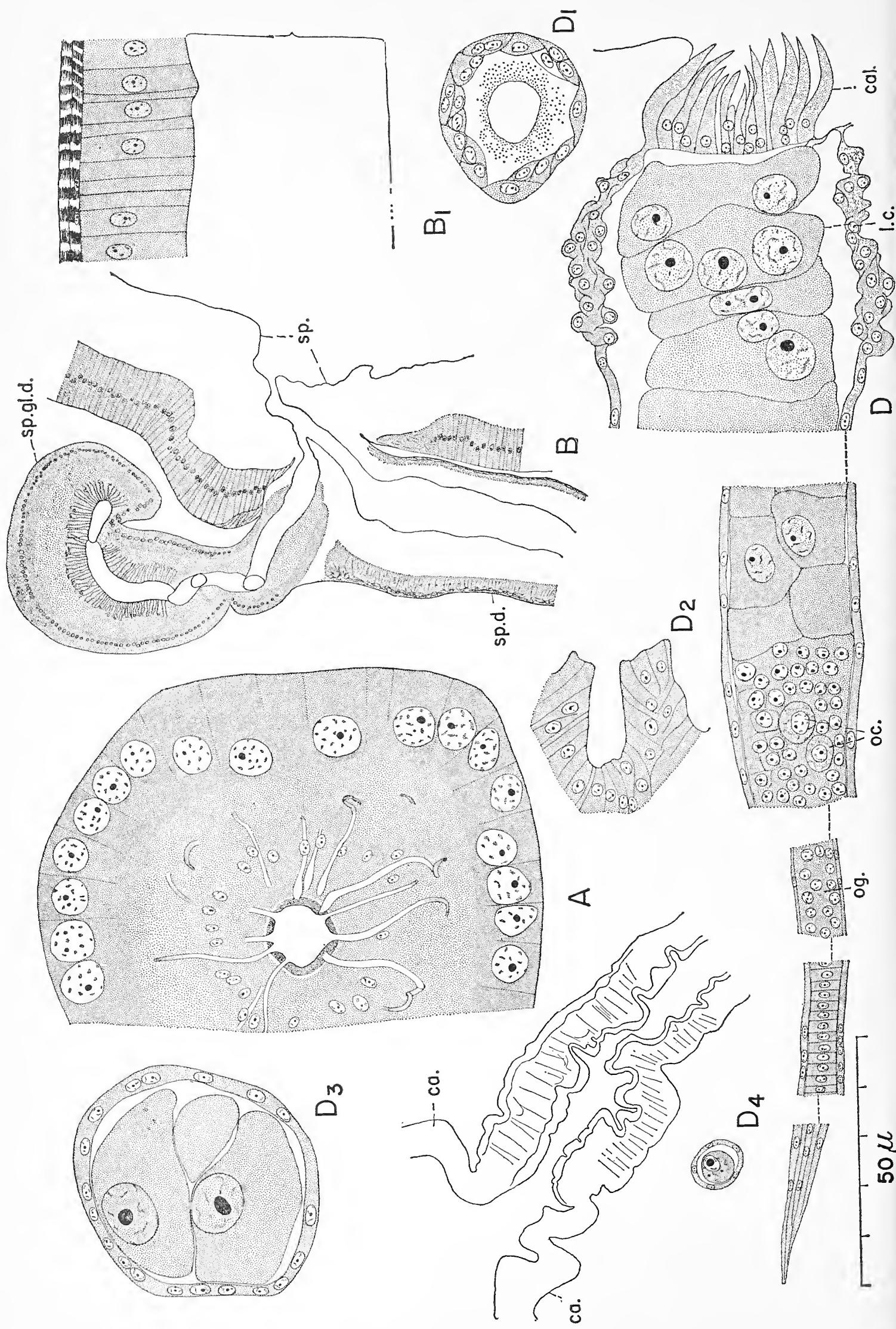
early physogastry, the lumen of the oviducts is empty. As physogastry advances, eggs move first into the paired oviducts, and then to the median oviduct until the common oviduct at maximum physogastry may contain 10–24 mature eggs, and each of the paired oviducts 30–60 eggs. These eggs invariably have their long axis parallel to the long axis of the duct containing them. During this period, the outer longitudinal muscle fibres become widely and irregularly separated and the inner layer of muscle fibres clearly show their striated nature except in the region in which nuclei occur (Fig. 12, F, G, H). This inner muscle layer now has the fibres more irregularly separated. The occasional large nuclei still present are separated from the muscle tissues, and slightly flattened.

At the end of physogastry, the oviducts quickly shrink to their narrow state (Fig. 10, C).

At its upper end, each oviduct flares out into a large fusiform chamber, the calyx of the ovary; though the name does not seem apt in *Eciton*. The wall of this chamber may be separated into two areas of different structures most clearly seen in callow queens. One of these areas comprising about one-tenth of the total area of the wall is characterized by its uniformly thin smooth wall. It is through this area at a point slightly posterior to its mid-point, that the oviduct opens.

The remaining nine-tenths is not so easily described, since both surfaces are covered by specialized structures. The inner surface is almost entirely covered by rings of scale-like cells 10–30 μ long and 6–15 μ broad at the base (Fig. 10, D, cal.). The scale-like cells occur in regularly circular groups, two to four layers thick (Fig. 10, D₁). When first formed, these cells fold inward at their pointed apices, leaving either a very small opening, or none at all. They become more or less erect, or partially reflexed, much like the calyx of certain flowers. The term calyx describes this structure rather than the entire chamber.

The nature of the tissue beneath these cells is difficult to clearly describe partly because it varies from one to another of the units and partly because it varies greatly as development progresses. In its earliest state these scale-like cells rest on a mass of small irregular cells which form a nearly continuous layer. In the center of this layer, is a small cylindrical pit rounded at its lower end (Fig. 10, D₂). Further development leads to the enlargement



of this pit or to the breakdown, or separation of the small cells, to form a large opening at the base of the scale-like cells. This opening enters the base of an ovariole. The ovariole wall and the ring formed by the base of the outer scales become continuous, and are connected with adjoining ovarioles by a layer of small irregular cells. In each ovariole, the wall is a continuous layer 1.5–2.5 μ thick from the base to near the apex, where it joins with a group of closely massed long cells which gradually narrow until only a single acute tip remains free in the haemolymph. At the base of the ovariole, the wall is usually much wrinkled at this stage, with the membranes separating the component cells indiscernible.

Within the wall, the basal half or more of each ovariole is filled by large cells. In one early callow queen, these large cells occupy about three-quarters of the length of each ovariole. Characteristically, the lowest ones are more or less discoid, unequal in thickness, and multinucleate (Fig. 10, D). Usually these cells do not quite fill the cavity formed by the ovariole wall. Further up in the ovariole, these large cells become irregular so that two to four of them are at the same level (Fig. 10, D₃). In all but some of the lowermost ones, each has a single large spherical to discoid nucleus.

Near or more frequently above the middle of the ovariole, these large cells cease and a mass of small irregular cells is found. The change is always sharp. It is not always possible to see cell

FIG. 10. Reproductive system of queen.

- A t.s. spermathecal gland showing ductules opening into central lumen; also small and large nuclei
- B Junction spermathecal duct (sp.d.), spermathecal gland duct (sp.gld.) and spermatheca (sp.)
- B₁ Wall of spermatheca
- C Outline, upper end of oviduct and small portion of calyx wall (ca.)
- D Ovariole of callow queen, showing calyx-like cells around lower end (cal.), wrinkled ovariole wall at lowest portion; large cells within (l.c.) oöcytes (oc.), oögonia (og.), disk-shaped cells and apical group of elongate cells
- D₁ t.s. ovariole, near base
- D₂ l.s. ovariole at base
- D₃ t.s. ovariole above base showing large cells
- D₄ t.s. zone of disk-shaped cells

membranes, especially in the central part of the mass (Fig. 10, D, *oc*). These small nucleate cells occur in nearly the entire length of the upper ovariole, being replaced near the apex by a row of uniform discoid cells (Fig. 10, D, left, and D_4). Near the apex, these cease, the long slender cells described above forming the apex of the ovariole (Fig. 10, D, extreme left). These ovarioles almost cover the entire chamber of the ovary except for the smooth area noted above.

The usual development described in all ant species occurs in this upper part of the ovariole. Certain cells increase in size, and become enveloped in a specialized layer of cells, the follicular epithelium, which soon surround the rapidly enlarging oöcyte except for a small region at the upper end. Above each oöcyte, a group of large irregular cells develop, each one containing a large nucleus. These are the trophocytes or nurse cells. This occurs in the upper part of each ovariole of a callow queen while the large cells filling the basal half persist unchanged. Presently, these large cells begin to break down and disappear, this process beginning with the lowermost and progressing upwards until the entire mass of cells has completely disappeared. The now nearly mature oöcytes, some of which are becoming invested with the two membranes characteristic of mature eggs, are slowly moving to the lower part of the ovariole. Before this movement has progressed very far, the lower part of the ovariole wall has become greatly wrinkled.

As the queen passes through late callow and into post-callow condition, certain changes occur in the reproductive organs. Most obvious among these is the increase in size of the chamber of the ovary, which doubles its length. The diameter also increases, but not as much as the length. Concurrently, the length of each of the many ovarioles has increased to about the same degree as has the chamber; this increase of the ovariole is accompanied by a change in the cells of the ovariole, the large cells of the lower half gradually becoming dissolute, the small oögonial cells of the upper half increasing in numbers and gradually pushing downward to fill the lower part of the ovariole. Two other less obvious changes have occurred—the first, a gradual elongation and thinning of the scale-like cells of the calyx-like structure, has been noted earlier: the other is a pronounced irregular wrinkling of the wall of the chamber, a change somewhat ob-

scured by the structures growing from the surface. These four changes are the result of growth with age, and are not cyclic.

During the first two to three days of the nomadic phase, each ovariole is formed principally of a long mass of small oögonial cells. Towards the end of the second or early on the third day, small oöcytes are seen in the lowest part of each ovariole. Occasionally one, or more, partially absorbed eggs (the partially collapsed and wrinkled egg membranes being noticeable) are seen in the lower end of some of the ovarioles. This occurrence may indicate that the queen is old. From the second through the ninth day of the nomadic phase, no conspicuous change occurs: during this interval, there is a gradual increase in the number of oöcytes in each ovariole, accompanied by the formation of a layer of follicular cells around the lowermost of the oöcytes, and the differentiation of groups of nurse cells, or trophocytes, between successive oöcytes in the lower part of the ovarioles.

No study of further changes were possible since queens collected during this part of the nomadic phase were lacking. In queens fixed at the end of the nomadic phase, nearly all the ovarioles have in the lower end one or more mature eggs, identified by the presence of chorion and vitelline membranes. Also, there is the long series of gradually decreasing oöcytes, the lower ones surrounded by follicular epithelial cells, the upper ones without such. Above these, extending nearly to the apex of the ovariole is the long mass of oögonial cells. The most characteristic feature of these ovarioles is the gradual series of cells, from the small undifferentiated cells at the apex to the mature eggs at the mouth. There is striking uniformity of the ovarioles in six queens, fixed on the second day of this phase.

The interval, including the last two or three days of the nomadic phase and the first five or six days of the statary phase, shows considerable variation in the rate of development of the cells of the ovarioles; especially in callow and post-callow queens. Frequently, it is during this interval that mature eggs begin to accumulate in the lower part of each ovariole. There is still one obvious difference—in many queens, the transition from mature eggs to not more than half-developed oöcytes is conspicuous; in other queens, there is no obvious region of separation, each ovariole has a graduated series of cells from the uniformly small undifferentiated cells at the apex through a gradual series of oöcytes

and into a series of maturing eggs. These may be differences between queens that are always observable. In any case, all the queens studied reach the same state at or just after the middle of the statary phase, the ovary then containing a large number of mature eggs. The number in each ovariole varies from five to ten, of uniform size, with a gradually decreasing series in the upper part of each ovariole. It is at about the same time that the first eggs are observed in the chamber of the ovary. No exact timing is possible after this event—eggs become more and more numerous in the chamber, appear in the paired oviducts, move into the median oviduct and finally appear in the vagina. During this period, of several days duration, one may count 200–300 eggs in the ovarian chamber, 50–60 in each of the paired oviducts, 20 or more in the median oviduct, but only four or five in the vagina. These eggs are invariably exactly oriented, the longitudinal axis of the egg paralleling the longitudinal axis of the containing part. Nor do the eggs ever show any evidence of distortion of shape due to crowding. Only at the end of this phase are eggs with distorted shapes found. These have been mentioned earlier as characterizing older queens. During the most active egg deposition, eggs are rarely found in the genital entrance or in the bursa copulatrix.

Unfortunately, no *mature* queens taken in the last few days of the statary phase were available for study. The two queens taken nearest the end of this phase were both young individuals, which became the functional queens of new colonies more than a month before capture, subsequent to the division of the parent colonies a few days after their emergence as callows (Schneirla, 1956). The colony of queen '52 H–J, *E. hamatum* completed one nomadic phase following colony division, and was in the fifteenth day of a statary phase when the queen was captured. A large brood of embryos and recently laid eggs were present, and obviously the queen had nearly completed laying her first lot of eggs. The colony of queen '52 B–Is, *E. burchelli* had also completed one nomadic phase after division, and was in the thirteenth day of the ensuing statary phase when the queen was captured. Embryos and recently laid eggs, estimated at more than 100,000, was found in the colony at the time. The ovaries of these two queens differ considerably, that of *hamatum* having many mature eggs in the chamber, oviducts, and ovarioles, with an abrupt transition

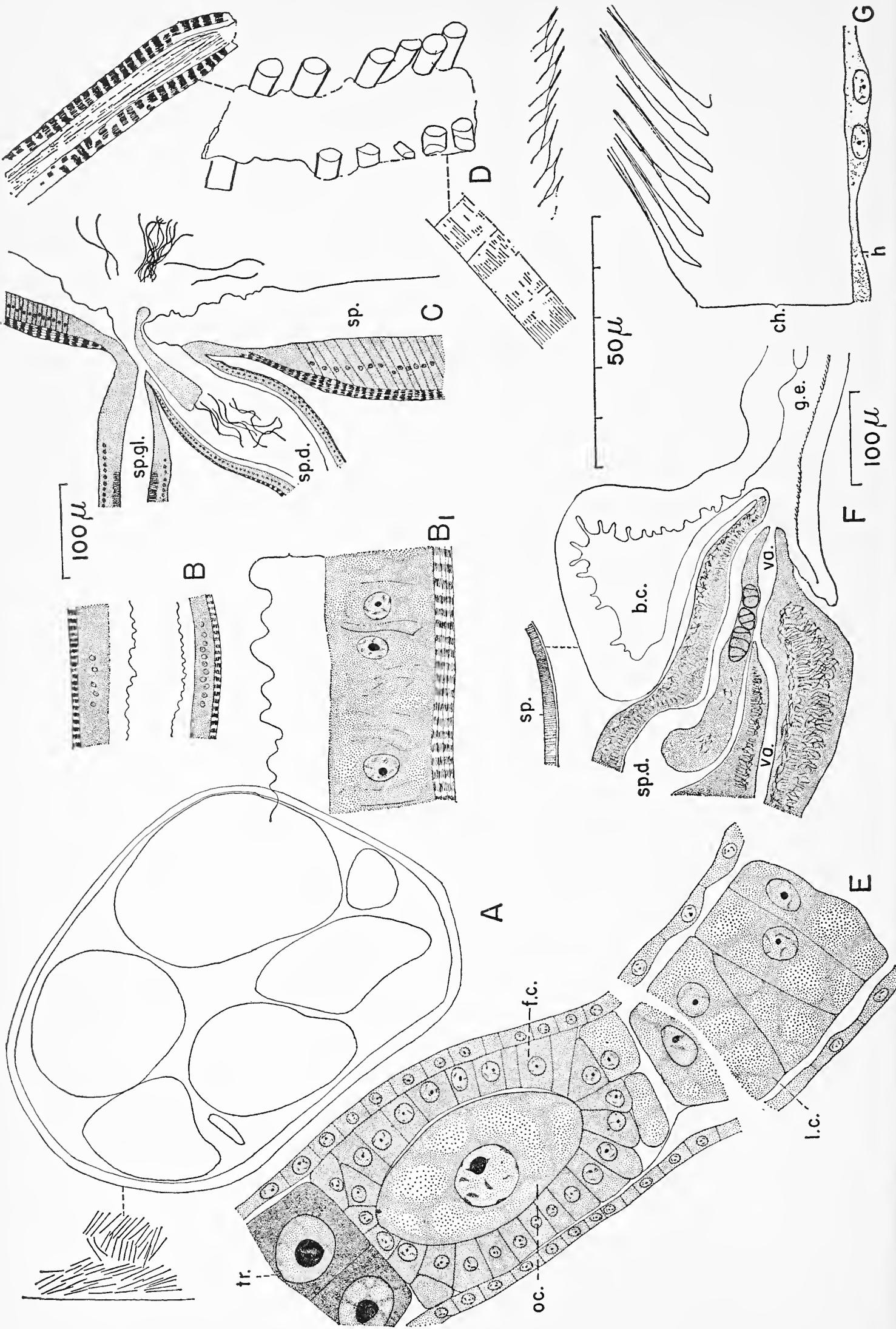
from the uppermost egg to a short region of undifferentiated small cells. The ovary of the *burchelli* queen, in contrast, contains not a single egg, and suggests that she had completed her egg deposition. Callows usually are abnormal in their ovarian structures. It seems reasonably that this *burchelli* queen shows the change typifying the end of the statary phase; inasmuch as there is a sudden cessation of egg development, with a row of mature eggs gradually leaving the ovarioles, but no cells developing to replace them.

In prepared sections, the spermatheca is the most conspicuous object in the gaster, especially when filled with sperms, stained dark blue or black by haematoxylin. Eight of the queens studied here are callow, these callow queens have a dense mass of sperms in the spermatheca.

The shapes of the spermathecae varied—two were nearly spherical, the two dimensions of the sagittal sections being 2440 and 2430 μ in the larger, and 1680 and 1660 μ in the smaller one: several were irregularly ovoid, the upper half slightly larger than the lower, or ellipsoid, or even angular. The largest spermatheca measured 3010 μ from top to bottom and was 2020 μ wide; the smallest of these measured 1900 by 1680 μ , larger than the unusually spherical one noted above. Nearly all seemed tilted forward.

The wall of the spermatheca is thick and shows three distinct layers of which the middle one is usually most striking (Fig. 10, B₁). This is formed of tall columnar cells, each containing a single spherical or ellipsoidal nucleus. The nuclei are so regularly located in the cells that they usually form an even layer around the spermatheca; in some individuals, this layer of nuclei is near the base of the cells; often it is in or near the middle of the cells. This layer averages 25–35 μ in thickness; but may vary from 15–50 μ . In nearly all the queens, this layer was uniformly thick; but in few, it was formed of cells varying length, such that the entire layer showed a pattern of uniformly large conical crests evenly spaced on its inner surface. In such cases, the cell at the peak might have a length of 35 μ , those in the thinnest areas measuring only 12 μ .

Within this layer, is a thick intima usually showing a stratified structure, the thin lines separating these strata being vaguely parallel, if one may so describe lines that may be broadly and



often irregularly sinuous. The inner surface of this intima is sharply defined and is usually unevenly and finely sinuous. This intima varies from 40–65 μ in thickness, but is uniform in each individual.

Externally, there is a thin layer of muscle fibres (8–13 μ thick) encircling the spermatheca in a plane parallel to the sagittal section of the gaster. In one large spermatheca, this muscle layer was only 2–3 μ thick, possibly due to the large mass of sperms in the spermatheca.

The spermathecae of the virgin queens, instead of containing sperms are filled with a substance which is uniform throughout the cavity of the spermatheca, and contains many minute granules.

Contents of the spermathecae of the fertile queens are not so easily described due to the conspicuous differences, perhaps indicating the gradual change that occurs during the life of the queen.

Several of the callow queens were found to be fertile.* In each

* Six such queens were available for this study, of which five were captured from the daughter colonies in which they had been established as the single queens for periods between 8 and 31 days after colony division. These were queens '48 H-27_{II}, *E. hamatum*, and '52 B-I_N, '52 B-I_S, '52 B-V, and '55 B-IV_N, *E. burchelli* (Schneirla, 1956). The second, third, and fourth of these queens had delivered their initial batches of eggs before the time of capture.

FIG. 11. Reproductive system fertile queen.

- A Spermatheca with "balls" of sperms; left, part of a sperm "ball," showing surface of embedding substance
 - B l.s. long spermathecal duct, near middle
 - B₁ Detail, wall of spermathecal duct
 - C Detail, spermathecal duct (sp.d.) and a sperm gland (sp.gl.) with part of spermathecal wall (sp.) and sperms in duct and spermatheca
 - D Foreign objects found in spermatheca
 - E Portion of ovariole, large cells (l.c.) in lower portion, oocyte (oc.) in follicular epithelium (f.e.) and nurse cells (tr.)
 - F Detail, union of vagina (va.), spermathecal duct (sp.d.), genital entrance (g.e.) and bursa copulatrix (b.c.)
 - G Detail, ventral wall genital entrance, hypodermis (h.) and chitin (ch.) with rows of spines and edge of opposing (upper) wall
- Scale: B₁, D, E and G = 50 μ scale; B, C, and F = 100 μ scale.
A = semidiagrammatic

of these queens, spermathecal contents are massed into about eight large ellipsoidal balls (Fig. 11, A). The orientation of the sperms indicates that at the time of fixation these balls were probably in some sort of rotatory motion that caused the sperms to become parallel. Each of these masses is contained in a sharply outlined non-staining substance extending beyond the sperm mass to form an enveloping layer 2–3 μ thick. These sperm masses vary in size, the largest having a length approximately half the diameter of the spermathecal lumen, the smallest measuring less than one quarter of that diameter.

In addition to the sperm balls, are many smaller masses or particles. Some of these are readily identified as small masses of densely aggregated sperms. But others are not so easily identified—among them are smaller masses of muscle tissue in which striations are sharp; other particles seem to be pieces of some coarse spine-like objects, occasionally combined with muscle-tissue or alone; some seem to be small tubes with muscular walls surrounding compact masses of parallel sperms; and some are indeterminate (Fig. 11, D). Possibly, these small objects are from the body of the male even though hasty examination of male abdomens fails to identify them.

In queens, definitely not callow and presumably much older, similar sperm balls are occasionally found in the spermatheca. In these queens, however, there is one striking difference from the callows, that being the presence of a uniformly thin aggregate of sperms throughout the space between the balls. Here also, the balls seen are more irregular in shape, more numerous, and often flattened as if by mutual pressure. Nor were any foreign objects observed here.

In the majority of the queens, the sperms form a single mass

Dr. Schneirla informs me that the sixth of these queens, '48 H-12, *E. hamatum*, was the only one captured before complete division of her parent colony. Since numerous callow *Eciton* queens of this class previously studied by Hagan (1955) and by me have been without sperms, this queen is the first callow discovered to have been fertilized before the completion of colony division. It is Dr. Schneirla's conclusion that this queen, the first of the virgin series to issue from the bivouac of her colony, and removed from her entourage of workers at that time for fixation and preservation (p. 286,—Schneirla and Brown, 1950), had emerged from her cocoon only two or three days earlier, hence must have been fertilized in the bivouac in the intervening period.

that fills the lumen of the spermatheca. In some of the queens, this is a uniformly dense mass of irregularly grouped, entangled sperms. In many of these, are found "pores" penetrating throughout the mass. These "pores" are about $10\ \mu$ in diameter. In other queens, the number of sperms per unit of volume becomes progressively less until the number is small and single sperms are widely separated. A decreasing sperm supply in the spermatheca eventually leads to re-insemination of the queen.

The paired spermathecal glands are long, much curved bodies gradually narrowing to a slender rounded apex. Originating on the anterior-dorsal surface of the spermatheca, each of the pair soon turns abruptly, sometimes upward, often laterally, but more frequently downward over the spermathecal surface, eventually ending in the ventral part of the gaster.

The structure of these glands is uniform from base to apex; that of callow queens differs noticeably from that of older queens. In the callow queens, there is on the outer surface a prominent membrane having a single layer of large columnar cells. Each cell contains a single spherical nucleus $8-10\ \mu$ in diameter. Membranes separating these cells are clear laterally; they may occasionally clearly show on the upper surface in callow queens, but not in older ones. Within this layer of cells, distinguished by its darker staining, is a lighter staining region containing fine ductules. These ductules narrow gradually from the base, which is $1.5-1.7\ \mu$ in diameter, to the apex of about $0.5\ \mu$ in diameter. In all ductules, the apex is usually loosely coiled or irregularly curved, and filled with a dark-staining substance. In callow queens, many small ellipsoidal nuclei measuring $1.5-2$ by $3-4.5\ \mu$ form an irregular layer near the mid-portion of these ductules. No cell membranes were found in this region (Fig. 10, A). In older queens, nuclei were never found in this region. Surrounding the central lumen of the spermathecal glands, is a dark-staining zone about $2\ \mu$ thick; passing through this layer, the mouths of the ductules flare widely. The diameters of these spermathecal glands vary from $100-140\ \mu$.

The spermathecal duct in its usual appearance has been well described by Hagan—an unusually long tube, flattened near its union with the vagina, then cylindrical throughout the rest of its length; and having several tight coils. These coils vary greatly, the component rings being sometimes tightly adpressed one to

another, sometimes loose, and sometimes absent and replaced by loose irregular loops.

In callow queens, the spermathecal duct differs from that of older queens. In one callow queen, the duct passes downward over the anterior surface of the spermatheca to the level of the median oviduct. Here, the spermathecal duct turns anteriorly and forms a compact irregularly contorted mass. From this mass, the duct passes posteriorly above the median oviduct to end in the dorsal surface of the vagina near its anterior end. In this queen, there is no sign of coiled regions anywhere in the duct. Apparently, continued elongation of the midportion of the duct causes loops to extend anteriorly, and eventually to become pairs of tightly coiled rings of varying length and numbers.

Throughout the greater part of its length, this spermathecal duct is formed of three distinct layers (Fig. 11, B); only in its posterior portion are there four layers, of which two outer layers cannot easily be observed. Surrounding the central lumen, is a thick intima, the inner edge of which is sharply defined. In many individuals, the lumen is greatly reduced by the deep folding of the inner surface of the intima—in extreme cases, nearly obliterating the lumen. At the other extreme, the inner surface of the intima is nearly smooth, and the lumen cylindrical except in the flattened posterior portion. Surrounding the intima, is a single layer of cuboidal cells, each with a single nucleus, $6-8\ \mu$ in diameter (Fig. 11, B₁). Membranes bounding these cells are seldom demonstrable, though some dark lines are identifiable as separating membranes. Externally, a third layer is usually in contact with the cellular layer. It is muscular with well-defined striations. These muscle fibres parallel the axis of the duct. In the posterior part of the duct, including the flattened part and varying lengths of the cylindrical portion anterior thereto, a fourth layer composed of muscles, encircles the duct. In these circular muscles, striations are less pronounced than in the longitudinal ones.

The dimensions of the spermathecal duct vary from scarcely $100\ \mu$ in diameter to nearly $200\ \mu$. Equally great is the variation of the component layers of the duct, the intima often exceeding the cellular layer; less often, the cellular layer exceeding the intima. The muscle layer is thinner and more uniform than the others, being $4-7\ \mu$ thick, except near the posterior end when it thickens.

In three queens, the posterior part of the lumen contains curious elongated plugs of material, usually extending into the lumen of the vagina. These plugs are composed of a darkly staining substance containing a few sperms and several dark, septate ellipsoid conspicuous bodies (Fig. 11, F). Probably these queens were fecundated shortly before being fixed.

In many of the queens studied the entire length of the spermathecal duct is empty. In others, groups of sperms occur irregularly throughout its length. Some of these groups contain 12–24 sperms, others have an estimated several hundred and some groups may contain thousands. Examination shows the sperms are immersed in a non-staining jelly-like substance while in others, the sperms are free of any enveloping substance. When sperms are present in the duct, mature eggs, or very large oocytes are present in the ovaries. Sperms are often present in the upper end of the spermathecal duct, at least where the duct opens into the lumen of the spermatheca; this is independent of the state of the ovaries.

The union of the spermathecal duct and of the two glands and the way in which these open into the spermathecal lumen varies (Fig. 10, B : Fig. 11, C : Fig. 12, A, B, C). In one variation, the spermathecal duct passes over the anterior surface of the spermatheca to midway in the upper anterior quadrant. As the duct nears this point, the lumen of the duct abruptly enlarges and enters the wall of the spermatheca, where the muscle layer fails to envelop it. Where the duct joins the spermatheca, the two spermathecal glands also join the spermathecal duct, one from each side, so that the lumina of the two glands join the lumen of the duct separately on the dorsal side just before the duct passes into the wall of the spermatheca. In a second, less frequent variation, the spermathecal duct passes dorsally along the anterior wall of the spermatheca. The two glands also extend upwards over the spermathecal wall, but well out towards the lateral surface. Near the level where the duct joins the spermatheca, the glands turn abruptly inward, approaching the duct from opposite sides. The lumina of the duct and the two glands enter the wall of the spermatheca separately, rapidly converge, and join at some point within the spermathecal wall, having a common opening into the lumen of the spermatheca. In a third variation, the duct and the glands join the spermatheca much as in the second case, but the three lumina unite so near the

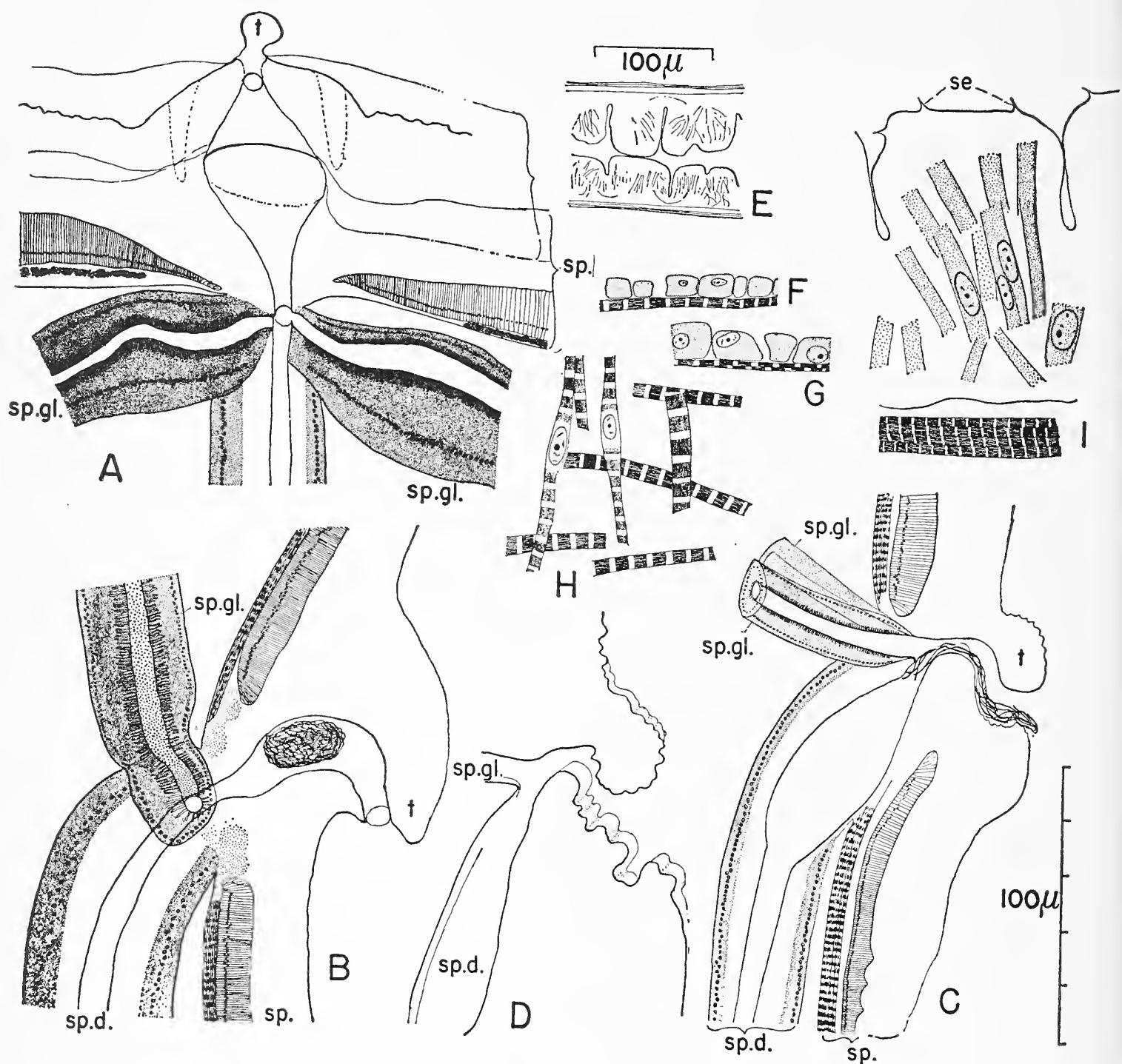


FIG. 12. Reproductive system.

- A Part of spermathecal wall (sp.), opening into spermathecal duct, openings of two spermathecal gland ducts (sp.gl.) and "tooth" (t.) Angle of section here exaggerates spermathecal wall thickness
- B l.s. spermathecal wall (sp.), spermathecal gland (sp.gl.), and spermathecal duct (sp.d.), with ball of sperms in lumen of duct

inner wall of the spermatheca that a wide invagination of the lumen of the spermatheca is formed; and into the inner end of this invagination, the lumena of the glands open separately.

The wall of the spermatheca is thicker around the opening of the spermathecal duct than elsewhere. Usually this thickness produces a low protuberance on the inner wall which may end in a peg-like knob, up to $8\ \mu$ in diameter and $15-20\ \mu$ long, projecting downward over and below the opening of the duct. This is evident when the opening is directed downward. The opening of the duct may occur through the lower part of the thickened region, and is then directed downward; or it may be through the central region, the opening then facing posteriorly. The actual opening varies from the circular to a broadly elliptical shape. The surface of the wall surrounding the opening may be smooth; often however, showing numerous unequal transverse wrinkles, some forming depressed areas $10\ \mu$ deep (Fig. 12, D). In many queens, this region contains many sperms, which stain heavily and thus conceal the nature of this region. Invariably a large mass of sperms collect in or near the opening of the spermathecal duct into the spermatheca. This sperm mass may be continuous with the mass of sperms filling the spermatheca.

In all workers, the reproductive system is of simple structure and unlike that of the queens (Fig. 8, B₁). From the smallest minors to the large soldiers, the structure is similar but differs in size. Occasionally, the system is absent or much reduced.

The reproductive system of the worker normally consists of the genital entrance, vagina, oviduct, an abortive spermathecal body and one or more ovarioles. The genital entrance is a broad shallow space, the walls of which are smooth; posteriorly, it is partially closed by the upturning of the posterior part of the

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- C l.s. spermathecal wall (sp.), glands (sp.gl.) and duct (sp.d.), with thin layer of sperms on duct lower wall
 - D Detail, inner part spermatheca wall and upper lumen of spermathecal duct (sp.d.), and lumen spermathecal gland (sp.gl.) shown at slight angle to emphasize wavy surface of wall
 - E l.s. median oviduct
 - F, G Upper (F) and lower (G) end of wall of a paired oviduct of nearly physogastric queen, showing muscle layers
 - H tg.s., fully inflated (with eggs) oviduct wall, showing muscle layers
 - I l.s. wall of median oviduct showing spines (se.) and muscles

ventral chitin wall. Anteriorly, scarcely any change marks the beginning of the vagina, there being little or no structure that can be called bursa copulatrix. The walls are cellular with small discoid nuclei and no obvious enveloping muscle tissue. In some workers, there is a small featureless structure rising from the upper surface of the vagina ending in a small, solid mass of cells; presumably spermathecal tissue. In other workers, a minute evagination of the dorsal wall of the vagina may be a spermathecal vestige. In many workers, such structures are absent and the dorsal wall of the vagina-oviduct tube is uniformly smooth.

The anterior end of this long slender tube divides to form two short tubes, the paired oviducts, at the end of which the ovarioles are found. In the workers studied the largest number of ovarioles noted was three on each side—six in all. Often, two were found and sometimes (especially in minor workers) only one. When three ovarioles occurred in an ovary, one ovariole was well-developed, the other two small. In ovaries with two ovarioles, the latter were of nearly equal size.

The structure of a worker ovariole is like that of the queens, but greatly reduced. The ovariole wall is a thin layer of squamous cells except at the apex, where a single short lash-like cell occurs. A small group of uniformly small cells is within the wall and as development continues, the cells of the lowermost part of the ovariole become differentiated, showing a large oocyte surrounded by a layer of small cells, the follicular epithelium (Fig. 8, B, left), and above this a short zone of large nurse cells. In workers studied no ovariole was seen having more than a single developing oocyte. In three individuals, mature eggs having a well-developed chorion and a thin vitelline membrane were found in the base of the ovarioles. One of these workers was a minor, the other two were majors. These eggs were one-third or less than the corresponding dimensions in eggs of queens.

Very little change in the heart and the digestive system is noted that can be correlated with the alternating contraction and physogastry of the gaster. The heart is slightly elongated during physogastry, and the posterior end may be pulled forward a bit; but any such changes are too small to be convincingly measured. Somewhat more obvious is the elongation of the intestine which at the height of physogastry is tautly stretched in many of the

queens; in others, the condition of the intestine lacks tautness.

The change of the peripheal glands in the gaster anterior to the spermatheca has been described earlier; one may recall that during physogastry, the gland cells are displaced to form a single layer, instead of the compact group two to four cells thick.

In the larger elements of the tracheal system, both in the main longitudinal trunk and in the larger branches, the change is obvious. In contracted queens, the walls of these trachea form many closely adpressed unequal folds: during the nomadic phase, these folds gradually spread as much as a two-fold increase in both the length and the diameter of the tracheal tube. This increase may continue into the early days of physogastry; but the mass of enlarging eggs seems to exert enough pressure to cause a decrease in the size of the tracheal elements before full physogastry is reached and a return of the folded condition of the walls.

Fat cells are numerous throughout the thorax and gaster, less abundant in the head. In the gaster, these aggregate in large masses, the fat bodies. Two changes probably occur in these fat cells during a reproductive cycle although they can not be demonstrated in the queens studied. That some queens have larger or more numerous amounts of fatty substance is indicated by the number and nature of the many vacuoles observed in the fat cells. The fatty material may have been removed during preparation of the material for study. The number of vacuoles increase during the nomadic phase, followed by a decrease as that phase ends. This change, however, is one that cannot be properly measured. The change in the nucleus in the fat cell is more easily observed: here again, it is not easy to set any limits for the change observed. In many queens, the nucleus is irregular, with a broad curving outline; in other queens, the nucleus of the fat cell is so collapsed that its outline shows only several irregular thin teeth projecting outward from a narrow body, an appearance usually described as stellate. The plump state of the nucleus is most frequent during the nomadic phase; the stellate, in the statary interval. But the distinction is not absolute—perhaps there are several factors leading to changes in the nucleus, imediately prior to fixation.

One other change is difficult to observe in its entirety. In queens fixed during the nomadic phase, the lumen of the spermathecal duct is empty, with the exception of small masses of

sperms frequently found in or near the opening through the spermathecal wall. Earlier in this paper, the presence of a "plug" of material in the mouth of the spermathecal duct of some callow queens was also noted. With these two exceptions, no visible substance is in this duct during the greater part of the nomadic phase. Only near the end of this phase does this condition change. In these final days, masses of sperms appear in the lumen of the spermathecal duct. These masses may be large, containing hundreds or even thousands of sperms, in some sort of unstained substance, the outer surface of which is distinct. Or the sperm masses may be small, containing not more than 100–200. Occasionally, small groups of perhaps a dozen sperms is seen. These groups are observed throughout the length of the lumen: sometimes, few in number and widely separated; sometimes, numerous and close together; seldom is there regularity in their distribution along the lumen. No queen was found with a continuous mass of sperms in the spermathecal duct. The presence of sperms in the duct is easily correlated with mature eggs in the ovarioles or in the tubes through which these eggs pass from the body.

(to be continued)

NOTES ON CONNECTICUT SPHAGNUM BOG

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ABSTRACT

A small Black Spruce bog in northeastern Connecticut is described, and some Lepidoptera from it listed.

Through the kindness of Edwin Way Teale of Hampton, Conn., I was able, in July 1961, to study and collect in a small bog at West Willington, Tolland Co., Connecticut.

No more than about 300 yards long and 50 to 100 yards wide, the bog is bounded on one side by a railroad track and on the other by the fill of a large gravel pit and its lower end is cut by the Wilbur Cross Highway. The construction of the latter probably altered the bog's normal drainage system. The bog is now in a rather late stage, containing no open water or floating mat,

and fast filling in centrally with small Black Spruce (*Picea mariana*) and Tamarack (*Larix laricina*), and peripherally with Alder (*Alnus incanus*) and Red Maple (*Acer rubrum*). None of the spruce are more than 10 feet high, but the dead stubs of considerably larger ones, evidently fire-killed, are common. Small spruce are abundant. The most characteristic bog heath, Labrador Tea (*Ledum groenlandicum*) is present in two fairly flourishing patches. The other shrubs are chiefly Leatherleaf (*Chamaedaphne calyculata*), Sheep Laurel (*Kalmia angustifolia*) and various *Vaccinium* and *Gaylussacia*. Only the Small Cranberry (*Vaccinium oxycoccus*) was found, and that not common. The substrate is thickly covered with dense billows of *Sphagnum*, and grasses and sedges are scarce, nowhere forming definite stands. The bog is, in fact, fast "closing in."

A number of Lepidoptera were collected on 12 and 18 July, some of which are particularly interesting and significant. These were:

Lycaenidae *Satyrium liparops strigosus* (Harris), a stray from the neighboring woodland. About 100 yards from the bog *Satyrium falacer* (Godart) and *S. caryaevorus* (McDunnough) were common, visiting *Ceanothus* flowers. **Hesperiidae** *Atrytone logan* (Edwards), a stray from nearby grassy meadow **Noctuidae** *Erastria albidula* (Guenée) and *Philometra eumelusalis* (Walker) are both common species of wet, grassy and sedgy areas and occur in many bogs but are by no means bog-limited. (Determinations by Frederick Rindge.)

Geometridae *Eufidonia discospilata* (Walker) is most often found in bogs, but also flies in wet meadows and open spaces (Determination by Frederick Rindge.) I have found it abundant in true bogs in Michigan and Ontario.

Pyralididae *Nomophila noctuella* (Schiffermueller) is cosmopolitan and abundant in all sorts of open meadows and marshes.

Glaphyria psychicalis (Hulst) is often common in wet, shaded woods and swamps.

Argyria nivalis (Drury) is common in meadows, dry to wet.

Raphiptera argillaceella (Packard) is highly characteristic of such *Picea* bogs from Labrador southward to at least New Jersey, and in Coastal Plain bogs to Florida and Mississippi. Only rarely does it stray far from bogs.

Crambus youngellus Kearfott (3 ♀ ♀ taken) is a most characteristic bog species, occurring only rarely and as a relict. Originally named from material from the large Mer Bleue bog near Ottawa, Ont., it has since been found only in a small, relict bog near Tuxedo, Orange Co., N. Y. and in bogs at Lakehurst, Ocean Co., N. J. (all captures by the writer).

Crambus bidens (Zeller), while not a characteristic bog species, is found around the edges of many bogs as well as in wet, more or less acid marshes; it occurs from Alaska to West Virginia, in the latter state in the edge of

a Black Spruce-Sphagnum bog in the mountains near Richwood, in Pocahontas Co.

Crambus albellus Clemens (abundant) and *alboclavellus* Zeller (common) are generally common in grasslands, the former particularly in wet areas, the latter in drier ones.

Tortricidae *Acleris minuta* (Robinson) was common, only the yellow variety being seen. Something of a Cranberry pest, this is a characteristic and widespread bog moth.

Acleris cervinana (Fernald), 1 specimen, (determined by N. Obraztsov), is a consistent bog moth, but also occurs in more normal swampy areas.

Olethreutidae *Badebecia urticana* (Hübner) occurs quite consistently in bogs, but abundantly in other open environments as well. It was common here.

Gelechiidae *Gelechia trialbamaculella* Chambers, 2 specimens. The identification is uncertain, awaiting revision of the group. I have this species from bog environments at Weymouth and Da Costa, Atlantic Co., N. J. but it is by no means bog-limited.

Of the above records, that of *Crambus youngellus* is the most interesting, showing the survival of a relict population of this rare species in such a very small bog. *Acleris minuta* and *Raphiptera argillaceella* are characteristic bog species, occurring more common and widely. The other species of moths are common in other open environments as well as in bogs.

Such true bogs should be located and recorded, and their biota studied, far more than is being done, since their relict populations are of special significance. Furthermore many bogs are being destroyed by encroaching civilization and all, of course, tend to disappear in the normal course of plant succession; so their study is particularly necessary. The writer would greatly appreciate being told about any bogs characterized by the presence in varying combinations of *Sphagnum*, *Ledum*, *Andromeda*, *Vaccinium macrocarpon*, and *oxycoccus*, *Kalmia polifolia*, *Sarracenia*, *Drosera*, *Pogonia*, *Menyanthes*, *Picea mariana*, *Larix*, *Chamaecyparis* and other true bog plants.

NOTES ON AXIOCERSES (LEPIDOPTERA: LYCAENIDAE)¹

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ABSTRACT

Locality records are listed and distributions mapped and discussed for *A. harpax*, *bambana* and *amanga*. The first two are contiguous but allopatric, the equator roughly dividing them (*harpax* to the north). One exception is a possible widely disjunct occurrence of *bambana* in Upper Guinea. Subspecies of *A. harpax* are described: *efulena* (Cameroun) and *ugandana* (Uganda, eastern Congo). A genitalic key to species is given.

The three most widely distributed species of *Axiocerces* are *harpax* Fabricius, *bambana* Grose-Smith and *amanga* Westwood, yet until recently (Stempffer 1957: 217, ff.) their correct identification was practically impossible. The first two, *harpax* and *bambana*, are so similar externally that they are effectively inseparable; and, though all three are subject to seasonal variation, in *amanga* this is so marked that the wet season and dry season forms have been considered distinct species.

Stempffer has shown that by means of the male genitalia all three species are readily and unequivocally identifiable, thus providing the means for distinguishing *bambana* and *harpax*, and uniting the seasonal forms of *amanga*. He has also provided an extensive list of localities for each species. These, combined with a number of additional localities in Carnegie Museum, provide a basis sufficient for a preliminary description and analysis of their distribution and, in the base of *harpax*, of regional variation as well.

Axiocerces harpax Fabricius

This species occupies a curious range (fig. 1, open circles): a band of territory from ocean to ocean, bounded to the south approximately by the equator, to the north about by the parallel of 15°. There are few or no records from the center of this band, but this is due, in all probability, to insufficient collecting. The known subspecies—there are four of them—are also curiously apportioned within this area. A narrow strip along the northern edge, from Senegal to Ethiopia and Eritrea, is occupied by the

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Fig. 1. Distribution of *Axiocerces harpax* (open circles) and *A. bambana* (solid triangles). Questioned spots indicate uncertainty of precise location and (*harpax* from Ubangi) uncertainty of correct subspecies assignment as well. The dashed lines separate approximately the subspecies of *harpax*: a, *kadugli*; b, *harpax* s.s.; c, *efulena*; d, *ugandana*. The subspecies of *bambana* are not distinguished.

savanna subspecies, *kadugli* Talbot. In addition to the localities given by Stempffer (1957), Carpenter (1935: 392, under *harpax*) records it from a number of places in the northern half of Ethiopia and (*teste* Joannis and Verity) in Eritrea. I have seen no specimens.

The remaining three subspecies are distributed, successively from west to east, from the Guinea Republic to Kenya in the rainforest belt.

A. harpax harpax Fabricius (= *harpax piscatoris* Clench 1943). Male. The fore wing above has the discal cell usually without the distal quadrate

orange patch; cell Cu_2 -2A is black in the base distad to about the origin of vein Cu_2 ; distad of the postmedian spots in $M_3-Cu_1-Cu_2$ there is no orange red; the postmedian spot is present in Cu_2 -2A, as a heavy black bar, crossing the costal half of the interspace. On the hind wing above there is extensive black on the costa and black fills the discal cell. Female. Similarly characterized by extension of black: the fore wing above usually lacks the distal quadrate orange spot in the discal cell; the base of cell Cu_2 -2A is black distad at least as far as origin of Cu_2 and often as far as the postmedian bar; the costa is black inward to M_1 , often more. On the hind wing the costal black is heavy, extending inward to M_1 at least.

The above description is based on specimens from Liberia as follows: Cape Palmas (*leg. Naysmith*), Harbel, Bomi Hills, Fish Lake and Wanau Forest (all *leg. R. M. Fox*). An additional pair of specimens is at hand from Accra, Ghana. Stempffer adds localities in Republic of Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Dahomey and Nigeria. All are probably referable to this subspecies, but Nigerian specimens (Stempffer *in litt.*) show a mixture of characters implying transition to the next subspecies. In the Ghana pair mentioned above there are also slight indications of this, suggesting that the zone of transition is a rather large one.

A. harpax efulena, new subspecies.

Male. Fore wing above always with an orange red quadrate patch in distal end of discal cell; cell Cu_2 -2A orange red to base, darkening progressively basad, but not black; the postmedian spots in $M_3-Cu_1-Cu_2$ usually (71%) with orange red spots immediately distad; the postmedian spot in Cu_2 -2A usually absent entirely, present in 22% of the specimens as a small trace only; hind wing above with costa only narrowly black and discal cell usually dark orange red with distal patch of bright orange red. Female. Fore wing above with distal quadrate orange spot always present in cell; cell Cu_2 -2A in base dusky orange as far as origin of Cu_2 (never black), and dusky never extends to postmedian spot; the costa is never black inward of M_1 and usually there is some orange distally in R_5-M_1 . On the hind wing above the quadrate orange spot always present in cell; costa with some orange always costad of M_1 distally.

Holotype male, Efulen, Cameroun, 27. ii. 1926 (*leg. H. L. Weber*) (male genitalia slide C-834); 110 paratypes, all Cameroun, as follows: Efulen, 36 males, 22 females, various dates (see below); Elat, 28 males, 11 females; Metet, 5 males, 1 female; Ebolewa, 2 males; Olama, 65 mi. ENE of Lolodorf, 1 male; Sakbayeme, 1 female; Sangmelima, 1 female; Bitje, Ja R., 1 male; Yoko, 1 female. C. M. Ent. type series no. 443.

Remarks. The distribution by dates of the Efulen series (including holotype and allotype) is as follows, the numbers following each month being respectively of males and of females: January, 2, 0; February, 5, 1; March, 3, 3; April, 3, 4; May, 4, 3; June, 2, 0; July, 2, 0; August, 1, 0; September, 1, 2; October, 11, 3; November, 2, 1; December, 1, 0. There thus appear to be two major flights, one cresting at about March or April, the other in October, the earlier one apparently more prolonged.

A. harpax ugandana, new subspecies.

Male. Fore wing above always with a quadrate orange red patch in distal end of discal cell; cell Cu_2 -2A black in base, distad to origin of Cu_2 ; the postmedian spots in M_3 - Cu_1 - Cu_2 usually (60%) with orange red spots immediately distad; the postmedian bleak spot in Cu_2 -2A present and strong in all specimens, almost completely crossing the interspace in two, crossing apical half in two, and about one-third in one. On the hind wing above the quadrate orange spot is always present in the cell; costa always with some orange costad of M_1 , and usually it is mostly orange.

Holotype male, Bugoma Forest, Unyoro, Uganda, iv. 1961 (*ex* T. H. E. Jackson) (slide no. C-918); 3 male paratypes: 1, same data as holotype; 2, Queen Elizabeth Park, Uganda, iii. 1961 (*ex* T. H. E. Jackson). C. M. Ent. type series no. 444.

Remarks. In addition to the type series there is at hand a male (slide no. C-836) from Medje, eastern Congo, vii. 1916 (*leg.* Lang and Chapin; *ex* American Museum of Natural History). Stempffer (1957:220) has recorded specimens from Ubangi (Talinga [=Yalinga ?]), northeastern Kenya and southern Ethiopia which with varying probability may refer to this subspecies. He also has noted (*in litt.*) its occurrence at Ngorongoro, Tanganyika, over 3° south of the equator.

Axiocerses bambana Grose-Smith

The following localities are represented in the Carnegie Museum collection: Congo: vic. Leopoldville; Angola: Gauca, 3600 ft. (ca. 20 mi. E of Quanza R. [nr. Neves Ferreira]); Chitau (Bihé Distr.); Nyasaland: Cholo, 2700 ft.; Ruo R.; Katanga: Elizabethville; Tanganyika (NE): Urungura Mts., 3000 ft. (*ssp. styx* Rebel). "Sierra Leone ?" (no further data). Stempffer (*in litt.*) adds the locality Cucumbi (prov. Lunda), Angola.

The principal portion of the range of this species (Fig. 1, solid triangles) lies wholly to the south of the area occupied by *harpax*, extending therefore from about the equator south into South-West Africa and the eastern Cape region. Nowhere does it overlap the range of *harpax*, but there are two potential zones of contact or near contact that deserve mention. First, in Kenya records show only *harpax* in the northwestern region; only *bambana* in the southeastern corner. Captures in the rather narrow intervening area (say, roughly, from Nairobi to Voi) might be very instructive. Second, along the west coast, only *harpax* is known from southern Cameroun; and from the vicinity of Leopoldville, on the Congo River, only *bambana* has been taken. It is curious, and perhaps significant, that despite large collections in Carnegie Museum from Gabon and Spanish Guinea there are no specimens from there of either *bambana* or *harpax*.

Does *bambana* occur in Upper Guinea? That question is raised by a few specimens of questionable authenticity. Stempffer (1957) mentions two of them—Sierra Leone and Gold Coast (Ghana). In a recent letter he writes that he has but one specimen from each, both from old collections and the data not beyond suspicion. In Carnegie Museum there is a pair, male (slide no. C-943; fig. 3B) and female, both labelled "Sierra Leone ?". These too

are old specimens and the data are doubted even on the labels. Adding to the interest of this problem is the fact that *A. amanga*, with a distribution (see below) strikingly similar to that of *bambana*, is definitely known to occur in Upper Guinea.

A. bambana styx Rebel. Stempffer (1957: 219) apparently did not know this subspecies and assigned it tentatively to *bambana* on the basis of its geographical location (Mt. Magara, Tanganyika, near Zanzibar). Two males are at hand (data given above) and the male genitalia of one of them show that it is indeed a *bambana*. The subspecies is quite distinctive. The orange red on the fore wing above extends no further costad than the middle of the Cu₂-2A interspace, the remainder of the wing being almost jet black. Elsewhere *bambana* males vary—individually—in the extent of the fore wing orange, but in the most extremely reduced of them the orange red still reaches vein Cu₂, and broadly; while the surrounding area of the wing, as usual in *bambana*, is dark grayish and shows the postmedian spots contrastingly darker even when they are not edged or surrounded by orange. The subspecies *styx* appears to have a very restricted range indeed. A short series of *bambana* from Mombasa, Kenya, very near *styx* territory, is nonetheless perfectly conventional *bambana*.

A. bambana subspecies. Stempffer (1957: 219, 220) mentions specimens from the arid region of northern South-West Africa as having the orange above light and the under surface dull: apparently a deserticolous form analogous to *harpax kadugli*. I have seen no material.

Axiocerces amanga Westwood

Localities in the Carnegie Museum collection: Congo: vic. Leopoldville; Angola; Huambo, 5400 ft. (Benguela Distr.); Chingaroi [Chinguar?], 2200 ft. (Benguela Distr.); Gauca, 3600 ft. (20 mi. E. of Quanza R. [nr. Neves Ferreira]); Transvaal: Messina; Rhodesia: Victoria Falls; Mineni Valley, Manica; Nyasaland: Cholo, 2700 ft.; Katanga: Elizabethville; Kenya: Mombasa; Kakamega; Cameroun (NW): Genderu, 4600 ft. [ca. 60 km. N. of Banyo] (ssp. *borealis* Auriv.). Localities in Natal and Transvaal are given by Swanepoel (1953: 163); Carpenter (1935: 392) gives localities in Ethiopia.

A. amanga, generally speaking, is considerably less common than either *harpax* or *bambana* (cf. Swanepoel 1953: 163) and records are correspondingly fewer. As with *bambana* its distribution (fig. 2) may be divided for purposes of discussion into two parts: the principal range, south and east of the Congo River; and Upper Guinea-Adamawa. The principal range is predominantly East African, extending from southern Ethiopia south to Natal. It reaches the west coast only from Angola to the Congo River. This range is similar to that of *bambana* save that in the east it extends considerably farther north, overlapping the range of *harpax* in and near Kenya, and does not extend quite so far south.

The range in Upper Guinea is still very inadequately known. Stempffer's records place it from the interior of Rep. Guinea eastward to Upper Volta and perhaps Soudan (Gao, on the middle Niger R.). To the east of these

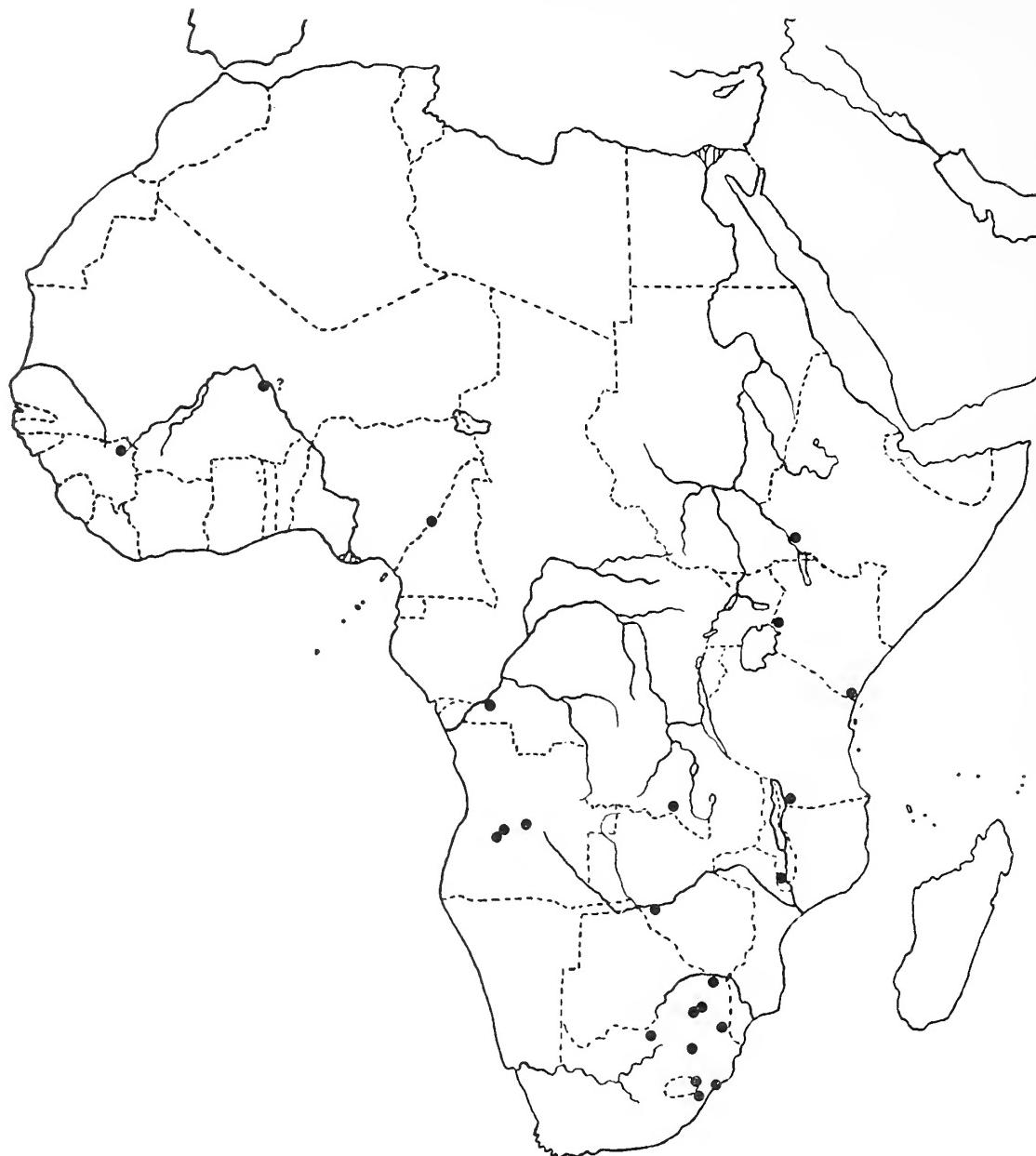


Fig. 2. Distribution of *Axioceres amanga*. The question indicates a locality, Gao, Soudan, cited by Stempffer and indicated by him as questionable.

localities occurs an apparently isolated population in the Adamawa highlands, described by Awrivillius as ssp. *borealis*. These highlands have yielded a remarkable assemblage of East African species (cf. Clench 1961: 58).

In view of the striking difference in appearance of the forms "mendeche" and "amanga" and of insufficient knowledge of the dates and places where they fly it is worth mentioning that both forms are represented in the museum collection, in series, from Angola: form "mendeche" from Chingaroi, 2200 ft., i. xii.1930; form "amanga" from Guaca, 3600 ft., 1-6.i.1931, and from Huambo, 5400 ft., 9.ii.1931. All these dates fall in the middle of the rainy season, so the difference here must lie in elevation: the "wet" form

"amanga" from the well watered highlands, the "dry" form "mendeche" from the considerably more arid lower elevations.

Subspecies of *amanga* are still virtually unstudied. Stempffer suggests that the Upper Guinea specimens before him differed slightly from "mendeche" from elsewhere, but he lacked sufficient material to be positive of it. The subspecies *borealis* differs, if the single male at hand is typical, in having the discal orange of the fore wing somewhat narrower and, particularly, in this orange not extending distad around vein 2A; below the basal silvery streak on the costa is noticeably thinner and shorter. In the limited material at hand Kenya males have an orange patch in the fore wing discal cell above, absent generally in those from elsewhere. More material must be seen to determine whether or not this warrants formal recognition: a remark that obviously applies to the other populations mentioned above as well.

Other *Axiocerces*

In addition to the three species discussed above the following species are also known to belong to *Axiocerces*: *jacksoni* Stempffer, 1948 (Ethiopia); *argenteomaculata* Pagenstecher, 1902 (Ethiopia); *punicea* Grose-Smith, 1889 (southern Kenya to eastern Rhodesia), *baumi* Weymer, 1901 (Angola). Of these I have seen only *punicea*, but Stempffer's description of *jacksoni* (1948: 191, fig. 2) includes illustration of the male genitalia, permitting inclusion of this species in the key below.

The genus would appear divisible into two groups: one, including *jacksoni* and *argenteomaculata*, smaller, "washed-out" in appearance, and apparently confined to Ethiopia. Possibly, as implied by *jacksoni*, the absence of a short process from the falcal elbow is characteristic of this group. The other group includes all the rest: larger, redder (especially below) and all of them I have seen have a characteristic short ventral process from the elbow of the falx; their distribution as a group extends as far north as Ethiopia but reaches its greatest development in the eastern and south-central areas of the continent.

The genus is above all an inhabitant of the savanna and thorn scrub country. Only *harpax* appears to have invaded the rain-forest.

Genitalic key to *Axiocerces*

Note: *baumi* Weymer and *argenteomaculata* Pag. not included.

- 1 a. Falx regularly rounded at elbow, without process.....*jacksoni* Stempff.
- b. Falx abruptly and sharply angled at elbow, with a short ventral process there

- 2 a. Mesial cleft of fultura inferior extends anteriorly to approximately the level of the dorsal cross-connection of the valvae, and well proximad of the lateral shoulders of the valvae, which may or may not be distinct 3
- b. This cleft extends anteriorly only to about the level of the distinct lateral shoulders of the valvae, well distad of the dorsal cross-connection of the valvae *punicea* Gr.-Sm. (fig. 3A)
- 3 a. Arms of fultura inferior long and digitate, roughly coterminous with distal ends of valvae; lateral shoulders of valvae very pronounced *amanga* Westw. (fig. 3D)
- b. Arms of fultura inferior distinctly shorter than valvae; lateral shoulders of valvae not prominent 4
- 4 a. Fultura inferior very short, its arms rounded, lightly or not at all toothed, ending about opposite lateral shoulders; dorso-mesial edge of valva usually with a slight, rounded, toothed process just distad of cross-connection *bambana* Gr.-Sm. (fig. 3B)
- b. Fultura inferior longer, its arms acute, usually densely toothed, ending just short of distal ends of valvae and distinctly beyond shoulders; no toothed process on dorso-mesial edge of valvae *harpax* Fabr. (fig. 3C)

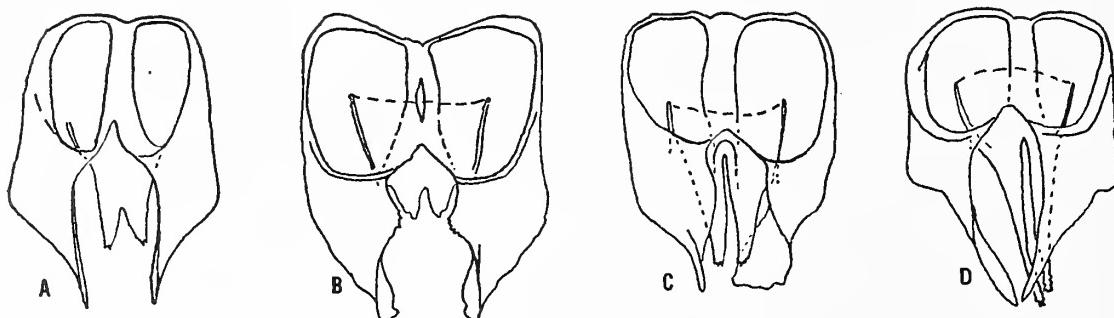


Fig. 3. Male genitalia (valvae, in dorsal view) of *Axiocerses*: A, *punicea* (Mombasa, Kenya); B, *bambana* (Sierra Leone?); C, *harpax* (Liberia); D, *amanga* (Angola).

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AN ANNOTATED LIST OF THE LYCAENIDAE (LEPIDOPTERA: RHOPALOCERA) OF THE WESTERN HEMISPHERE

BY WILLIAM PHILLIPS COMSTOCK AND EDGAR IRVING HUNTINGTON

[CONTINUED]

sichaeus Kirby, W. F., *Thecla* (not Cramer) see *sicheus* Cramer

Type Locality:

Location of Type:

Original Description: 1871, A Synonymic Catalogue of Diurnal Lepidoptera, p. 389, no. 153 (London).

sicheus Cramer, Pierre, *Papilio*

Type Locality: Surinam.

Location of Type:

Original Description: 1777, Papillions exotiques des trois parties du monde, vol. 2, p. 76, pl. 144, figs. C, D (Amsterdam).

Additional Reference: Kirby, W. F., 1871, A Synonymic Catalogue of Diurnal Lepidoptera, p. 389, no. 153 (London). (Makes *sichaeus* a synonym of *strephon* Fabricius.)

Synonyms: *sichaeus* Kirby.

sicrana Jones, E. Dukinfield, *Thecla*

Type Locality: Castro, Paraná, Brazil.

Location of Type: Jones Collection.

Original Description: 1912, Proc. Zool. Soc. London, p. 897, pl. 97, fig. 3 (London).

sidara Clench, Harry K., *Lycaenopsis pseudargiolus*

Type Locality: Manitou, Colorado, June 5-11, 1882.

Location of Type: Museum of Comparative Zoology.

Original Description: 1944, Jour. New York Ent. Soc., vol. 52, p. 273 (Lancaster, Pa.).

sierrae Dyar, Harrison G., *Thecla syncellus*

Type Locality: Sierra de Guerrero, Mexico, January, 1913.

Location of Type: United States National Museum, no. 19,252.

Original Description: 1917, Proc. U. S. Natl. Mus., vol. 51, p. 2 (Washington, D. C.).

Synonyms: *deserta* Draudt.

silensis Herbst, Johann Friedrich Wilhelm, *Papilio*

Type Locality:

Location of Type:

Original Description: 1800, Natur system aller bekannten in und ausländischen Insekten, vol. 10, p. 306, pl. 292, fig. 7 (Berlin).

Additional References: Kirby, W. F., 1877, A Synonymic Catalogue of Diurnal Lepidoptera, Supplement, p. 774, no. 84 (London). (Places *silennissa* in synonymy of *phaleros* Linnaeus.) Draudt, Max, 1919 (November), The Macrolepidoptera of the World, vol. 5, p. 752 (Stuttgart). (Places *silennissa* as a synonym of *phaleros* Linnaeus).

silenus Cramer, Pierre, *Papilio*

Type Locality: Surinam.

Location of Type:

Original Description: 1780, Papillons exotiques des trois parties du monde, vol. 3, p. 159, pl. 282, fig. E (Amsterdam).

Additional Reference: Kirby, W. F., 1871, A Synonymic Catalogue of Diurnal Lepidoptera, p. 384, no. 84 (London). (Makes *silenus* a synonym of *phaleros* Linnaeus.)

silenus Doubleday, Edward, *Thecla*

Type Locality:

Location of Type:

Original Description: 1847, List of the specimens of lepidopterous insects in the collection of the British Museum, pt. 2, p. 31 (London).

Note: This name appears to be Doubleday's for his reference to "Strymon Sil. Hübn. Zut. fig. 111-2" is incorrect and no Hübner name *silenus* seems to exist; but, Hübner described *Strymon melinus* in Zuträge, 1st 100, p. 22, no. 61, figs. 121, 122 (♂). *Silenus* may be considered as being in the synonymy of *melinus* Hübner.

silumena Hewitson, W. C., *Thecla*

Type Locality:

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 90, vol. 2, pl. 45, figs. 196, 197 ♂ (London).

simaethis Drury, Dru, *Papilio*

Type Locality: "St. Christopher's."

Location of Type:

Original Description: 1770, Illus. of Nat. Hist., vol. 1, p. 3, pl. 1, fig. 3 (London).

Additional Reference: Comstock, W. P. and E. I. Huntington, 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 73, pl. 1, fig. 6 ♂ (New York).

Synonyms: *lycus* Skinner.

Subspecies: *jago* Comstock and Huntington, *sarita* Skinner.

simasca Draudt, Max, *Thecla*

Type Locality: Rió Negro, Colombia.

Location of Type:

Original Description: 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 794, pl. 157-k (Stuttgart).

simplex Walch, J. E. J., *Papilio*

Type Locality:

Location of Type:

Original Description: 1775, *Der Naturforscher*, vol. 6, p. 130, pl. 6, figs. 3, a and b (Halle).Additional Reference: Kirby, W. F., 1871, *A Synonymic Catalogue of Diurnal Lepidoptera*, p. 389 (London). (Places *simplex* as a synonym of *pelion* Cramer).*sinepunctata* Comstock, John A., *Glaucoopsyche lygdamus behrii* var. *australis* ab.

Type Locality: California.

Location of Type:

Original Description: 1926, *Bull. Southern Calif. Acad. Sci.*, vol. 25, p. 48, fig. (Los Angeles, California).Additional Reference: McDunnough, J. H., 1938, *Check list*, pt. 1, p. 28, no. 473 Los Angeles, Calif.). (Places "sinepuncta" as an aberration of *lygdamus australis* Grinnell).Synonyms: *sinepuncta* McDunnough.*sinepuncta* McDunnough, James H., *Glaucoopsyche lygdamus australis* ab.
Misspelling of *sinepunctata* Comstock

Type Locality:

Location of Type:

Original Description: 1938, *Check list*, pt. 1, p. 28, no. 473 (Los Angeles, Calif.)*sinnis* Godart, Jean B., *Polyommatus*

Type Locality: Brazil.

Location of Type:

Original Description: 1822, *Encyclopédie Méthodique*, vol. 9, p. 625 (Paris).Additional Reference: Druce, H. H., 1907 (June), *Proc. Zool. Soc. London*, p. 568 (London). (Did not recognize the species)*sirius* Edwards, William H., *Chrysophanus*

Type Locality: Colorado (♂, ♀).

Location of Type:

Original Description: 1871 (March), *Trans. Amer. Ent. Soc.*, vol. 3, p. 270 (Philadelphia, Pa.)Additional Reference: McDunnough, J. H., 1938, *Check list*, pt. 1, p. 26, no. 429 (Los Angeles, Calif.). (Places *sirius* as a subspecies of *rubicundus* Behr).*sissona* Wright, William Greenwood, *Lycaena*

Type Locality: Sission, California, July.

Location of Type:

Original Description: 1906, Butterflies of the West Coast, 2nd Edition, p. 232, pl. 30, fig. 400 ♀ (San Bernardino, Calif.).

Additional Reference: Barnes, William and James H. McDunnough, 1917 (February), Check list of the Lepidoptera of boreal America, p. 16, no. 424 (Decatur, Illinois). (*Places sissona* as a synonym of *comyntas* Godart).

Note: The date of the species is 1905, from 1st Edition published by the Whitaker and Ray Company, San Francisco, California.

sista Hewitson, W. C., *Thecla*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 92, vol. 2, pl. 37, figs. 98, 99 ♂ (London).

sito Boisduval, Jean A., *Thecla*

Type Locality: Mexico.

Location of Type:

Original Description: 1836, Histoire naturelle des insectes. Species Générale des Lépidoptères, vol. 1, expl. pls. p. 6, pl. 22, fig. 5 (Paris).

Additional Reference: Hewitson, W. C., 1869 (April), Illus. of Diurnal Lepidoptera, vol. 1, p. 87, vol. 2, pl. 45, figs. 193, 194, 195 ♀ (London).

siva Edwards, William H., *Thecla*

Type Locality: Wingate, Arizona, July, 1874 (2 ♂).

Location of Type:

Original Description: 1874 (October), Trans. Amer. Ent. Soc., vol. 5, p. 110 (Philadelphia, Pa.)

Additional Reference: Holland, W. J., 1931, The Butterfly Book, Revised Edition, p. 231, pl. 30, fig. 9 ♂ (Garden City, N. Y.). (Said that the figure is that of the type).

Subspecies: *juniperaria* Comstock.

smaragdus Druce, Hamilton H., *Thecla*

Type Locality: Chapada, Brazil and Castro, Paraná, Brazil.

Location of Type: Godman Collection.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 599, pl. 35, fig. 13 ♂ (London).

smilacis Boisduval, Jean A. and John LeConte, *Thecla*

Type Locality: Georgia.

Location of Type:

Original Description: 1833, Histoire Générale et iconographie des Lépidoptères et des chenilles de l'Amérique Septentrionale, p. 107, pl. 33 (Paris).

Additional References: Dyar, Harrison G., 1902, Bull. U. S. Natl. Mus., no. 52, p. 38 (Washington, D. C.). (Makes *smilacis* a synonym of *damon*

Cramer). McDunnough, J. H., 1938, Check list, pt 1, p. 25 (Los Angeles, Calif.). (Makes *smilacis* a form of *damon* Cramer).

Note: *Smilacis* is the summer (drak) form of *damon* Cramer.

Synonyms: *patersonia* Brehme.

smithi, Mattoni, R. H. T., *Philotes enoptes*

Type Locality: Burns Creek, State Highway 1, Monterey County, California, August 20, 1948.

Location of Type: United States National Museum.

Original Description: 1954 (December), Bull. Southern Calif. Acad. Sci., vol. 53, pt. 3, p. 160, pl. 43, figs. 8, 9 (Los Angeles, Calif.).

snowi Edwards, William H., *Chrysophanus*

Type Locality: Above timber line on Gray's Peak, Colorado.

Location of Type:

Original Description: 1881, Trans. Kansas Acad. Sci., vol. 7, p. 69 (Topeka, Kansas).

Synonyms: *mcdunnoughi* Gunder.

Subspecies: *henryae* Cadbury.

socia Hewitson, W. C., *Thecla*

Type Locality: Brazil.

Location of Type: British Museum (Natural History).

Original Description: 1868, Specimen of a Catalogue of Lycaenidae in the British Museum, p. 29 (London).

Additional Reference: Hewitson, W. C., 1869 (April), Illus. of Diurnal Lepidoptera, vol. 1, p. 136, vol. 2, pl. 54, figs. 320, 321 ♂ (London).

socigena Hewitson, W. C., *Thecla*

Type Locality: Santa Martha, Colombia.

Location of Type: British Museum (Natural History).

Original Description: 1877 (January), Illus. of Diurnal Lepidoptera, vol. 1, p. 205, vol. 2 pl. 82, figs. 681, 682 ♂ (London).

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 584 (London). (Makes *socigena* a synonym of *vibidia* Hewitson).

socorroensis Draudt, Max, *Thecla*

Type Locality:

Location of Type:

Original Description: 1919 (December), The Macrolepidoptera of the World, vol. 5, p. 758 (Stuttgart). (Makes *socorroensis* Dognin in lit. a synonym of *fassli* Druce).

solatus Cook, John H. and Frank E. Watson, *Incisalia henrici* var.

Type Locality: Blanco County, Texas, February and March.

Location of Type: Type destroyed. (Paratypes in the American Museum of Natural History, and the United States National Museum).

Original Description: 1909 (June), Can. Ent., vol. 41, p. 181 (Guelph, Ont.).

sonoralba Watson, Frank E. and William P. Comstock, *Philotes sonorensis* ab.

Type Locality: San Diego, California.

Location of Type: American Museum of Natural History.

Original Description: 1920, Bull. Amer. Mus. Nat. Hist., vol. 42, p. 456 (New York, N. Y.).

sonorensis Felder, Cajetan and Rudolph Felder, *Lycaena*

Type Locality: Sonora, Mexico.

Location of Type:

Original Description: 1864-1867, Reise de Oesterreichischen Fregatte "Novara" um die Erde, vol. 2, p. 281, pl. 35, figs. 3, 4 (Wien).

Synonyms: *sonoralba* Watson and Comstock, *regia* Boisduval.

Subspecies: *comstocki* Gunder.

sophocles Fabricius, Johann Christian, *Hesperia*

Type Locality: "In Indiis."

Location of Type:

Original Description: 1793, Entomologica Systematica, vol. 3, p. 267 (Hafniae).

Additional Reference: Donovan, Edward, 1800, Ins. India, p. 43, pl. 40, fig. 2 (London).

Synonyms: *sphinx* Godart, *wilhelmina* Kirby, *virginia* Draudt.

sospes Draudt, Max, *Thecla*

Type Locality: Colombia.

Location of Type: Draudt Collection (1 ♂).

Original Description: 1920 (February), The Macrolepidoptera of the World, vol. 5, p. 788, pl. 155-e (Stuttgart).

souhegan Whitney, Charles P., *Thecla*

Type Locality: Milford, New Hampshire, July 20.

Location of Type:

Original Description: 1868 (December), Proc. Boston Soc. Nat. Hist., vol. 12, p. 162 (Boston, Mass.).

Additional Reference: Watson, F. E. and W. P. Comstock, 1920 (December), Bull. Amer. Mus. Nat. Hist., vol. 42, p. 449 (New York, N. Y.). (Consider *souhegan* to be a subspecies of *acadica* Edwards).

Synonyms: *swetti* Watson and Comstock.

spadix Edwards, Henry, *Thecla*

Type Locality: Tehachepi Pass, Southern California.

Location of Type: American Museum of Natural History (2 ♀).

Original Description: 1881 (April), Papilio, vol. 1, p. 53 (New York).

Additional Reference: Barnes, William and James H. McDunnough, 1916, Contributions to the natural history of the Lepidoptera of North America, vol. 3, no. 2, p. 105 (Decatur, Illinois). (Retain the name *spadix* for a southern race of *auretorum* Boisduval).

spaldingi Barnes, William and James H. McDunnough, *Philotes*

Type Locality: Provo, Utah.

Location of Type: United States National Museum (Barnes Collection).

Original Description: 1917 (March), Contributions to the natural history of the Lepidoptera of North America, vol. 3, no. 4, p. 216, pl. 16, figs. 9-11, pl. 17, fig. 6 (genitalia) (Decatur, Illinois).

spangelatus Burdick, W. N., *Plebeius lupini*

Type Locality: Gray Wolf Range, Olympic Mountains, Clallam County, Washington, August, 1936.

Location of Type: Canadian National Collection.

Original Description: 1942 (October), Can. Ent., vol. 74, p. 195 (Guelph, Ont.).

sparsa Hayward, Kenneth J., *Thecla vena*

Type Locality: Villa Nogues, Tucuman, Argentina, January 21, 1931.

Location of Type: Fundación Miguel Lillo, Tucumán.

Original Description: 1949, Acta Zool. Lilloana, vol. 8, p. 574 (Tucuman, Argentina).

speciosa Edwards, Henry, *Lycaena*

Type Locality: Havilah, Kern County, California (1 ♂).

Location of Type: American Museum of Natural History (1 ♂).

Original Description: (1876), 1877, Proc. Calif. Acad. Sci., vol. 7, p. 173 (San Francisco, Calif.).

Additional Reference: Edwards, Henry, 1881 (April), Papilio, vol. 1, p. 55 (New York). (Describes the female).

speciosa Staudinger, Otto, *Cupido*

Type Locality: Huallatani, Bolivia.

Location of Type:

Original Description: 1894, Deutsche Ent. Zeit. (Iris), vol. 7, p. 77, pl. 2, fig. 8 (Dresden).

sphinx Godart, Jean B., *Polyommatus*

Type Locality: Surinam and Brazil.

Location of Type:

Original Description: 1822, Encyclopédie Méthodique, vol. 9. p. 632 (Paris).

Note: This is a synonym of *sophocles* Fabricius (see *wilhelmina* Kirby).

sphinx Fabricius, Johann Christian, *Papilio*

Type Locality: "India Orientali."

Location of Type:

Original Description: 1867, Species Insectorum, vol. 2, p. 116 (Hamburg).

Additional References: Hübner, Jacob, 1832, Zutrage zur Sammlung exotischer Schmettlinge, vol. 4, p. 13, figs. 635, 636 (Augsburg). Butler, A. G., 1869, Catalogue of Diurnal Lepidoptera Described by Fabricius in

the Collection of the British Museum, p. 187 (London). (Makes *P. sphinx* at above reference of a synonym of *P. dindymus* Cramer).

spinetorum Hewitson, W. C., *Thecla*

Type Locality: California.

Location of Type: United States National Museum?

Original Description: 1876, Illus. of Diurnal Lepidoptera, vol. 1, p. 94, vol. 2, pl. 45, figs. 198, 199 (London).

Additional References: Boisduval, Jean A., 1869, Ann. Soc. Ent. Belgique, vol. 12, p. 42 (Bruxelles). Godman, F. D. and O. Salvin, 1901 (October), Biologia Centralia-Americana, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 717, vol. 3, pl. 111, figs. 5, 6 ♂ (London). Oberthür, Charles, 1913 (October), Etudes de Lepidopterologie Comparee, fasc. 9, pt. 1, p. 42, pl. 238, fig. 1952 (Rennes).

Synonyms: *cuyamacaca* Wright, *ninus* Edwards.

spinimaculata Gunder, Jean D., *Plebeius icarioides* ab. ♂

Type Locality: Delta, Trinity County, California, May 22, 1925.

Location of Type: American Museum of Natural History.

Original Description: 1926 (January), Ent. News, vol. 37, p. 8, pl. 1, fig. 12 (Philadelphia, Pa.).

splendidissima Bryk, Felix, *Eumaeus minijas*

Type Locality: Roque, SO Moyobamba, Peru, April 20, 1925.

Location of Type:

Original Description: 1953, Arkiv för Zoologi, vol. 5, no. 1, p. 132 (Stockholm).

splendor Druce, Hamilton H., *Thecla*

Type Locality: Colombia.

Location of Type: Oxford Museum.

Original Description: 1907 (June), Proc. Zool. Soc. London, p. 570, pl. 31, fig. 4 ♀ (London).

sponsa Möschler, H. B., *Thecla*

Type Locality: Inner Surinam.

Location of Type:

Original Description: 1876, Verh. Zool.-bot. Ges., vol. 26, p. 298, pl. 3, fig. 2 (Wien).

spurina Hewitson, W. C., *Thecia*

Type Locality: Amazon.

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 102, vol. 2, pl. 39, figs. 122, 123 ♀ (London).

Synonyms: *erenea* Hewitson, ? *stagira* Hewitson, ? *timaea* Hewitson, *volana* Hewitson, *lydia* Kirby.

spurius Felder, Cajetan and Rudolf Felder, *Pseudolycaena*

Type Locality: Venezuela and New Granada, Bogotá.

Location of Type:

Original Description: 1864–1867, Reise der Österreichischen Fregatte "Novara" um die Erde, vol. 2, p. 250, pl. 31, figs. 23, 24 (Wien).

Synonyms: *dolosa* Staudinger.

stagira Hewitson, W. C., *Thecla*

Type Locality: Amazon (Santarem) and Rio de Janeiro.

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 113, vol. 2, pl. 39, figs. 120, 121 ♂, pl. 43, fig. 167 ♂ (London).

Additional References: Godman, F. D. and O. Salvin, 1887 (August), *Biology Centrali-Americana*, Insecta, Lepidoptera-Rhopalocera, vol. 2, p. 52 (London). (Say that Hewitson's figure 167 represents another species. Consider Hewitson's first figure solely as representing *stagira*). Druce, H. H., 1905, Ann. Mag. Nat. Hist., Series 7, vol. 15, p. 195 (London). (Places *stagira* as a synonym of *spurina* Hewitson.)

sternitzkyi Gunder, Jean D., *Lycaena thoe* tr. f.

Type Locality: Petaluma, California, August 1, 1927.

Location of Type: American Museum of Natural History.

Original Description: 1927 (December), Can. Ent., vol. 59, p. 285, pl. A, fig. 15 (Orillia, Ont.).

Note: The label on the holotype reads "helloides tr. f. sternitzkyi."

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 26, no. 432 (Los Angeles, Calif.). (Places the name as *Lycaena helloides* ab. *sternitzkyi* Gunder.)

sternitzkyi Gunder, Jean D., *Glaucopsyche lygdamus* race *behri* tr. f.

Type Locality: Fairfax, Marin County, California.

Location of Type: American Museum of Natural History.

Original Description: 1929 (December), Bull. Brooklyn Ent. Soc., vol. 24, p. 325, pl. 31, fig. 2 (Brooklyn, N. Y.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 28, no. 473 (Los Angeles, Calif.). (Places *sternitzkyi* as an aberration of *lygdamus behrii* Edwards.)

PROCEEDINGS OF THE NEW YORK ENTOMOLOGICAL SOCIETY

MEETING OF FEBRUARY 7, 1961

Dr. Schmitt called the meeting to order at 8:00 P.M. in Room 129 of the A. M. N. H. There were 17 members and seven guests present. The minutes of the previous meeting were read and accepted after correction. Mrs. Gaston Dubois was elected to membership. The following were proposed for membership: Mr. Glenn Foss, Mr. Leonard Goldentyer, Mr. and Mrs. Victor Roudin, and Dr. Harry L. Haynes. It was proposed to suspend the By-Laws on election. After the proper motions were made, all were unanimously elected to the Society.

Dr. Schmitt then presented Dr. Maynard Ramsey of the Plant Quarantine Division of the United States Department of Agriculture who spoke on, "How We Buttress Our Plant Pest Defense In A Changing World." The evolution of plant pest defenses and the problems brought about by modern transportation methods were described. During 1960 over 30,000 lots of plant pests were taken by inspectors. This means that one important plant pest was prevented from entering our country every 17 minutes on the average during the entire year. Not only are plant and animal products inspected, but motor vehicles and machine parts, too. Fumigation methods were described. The inspection division has a force of only 500 professionals, scattered over the entire country, to do this tremendous job. This work is aided by Customs, Immigration, Public Health Service, and Post Office Department personnel. A very interesting color and sound film, "The Hidden Menace," was shown. This depicted the interception and destruction of many plant pests. It urged all citizens, particularly, farmers, naturalists, and those interested in science to be part-time plant pest detectives and to help in this huge task of protecting our crops and health. A lively question and answer period followed. The meeting adjourned at 9:30 P.M.

RAYMOND BRUSH, SECRETARY

MEETING OF FEBRUARY 21, 1961

President Schmitt called the meeting to order at 8:10 P.M. in Room 129 of the A. M. N. H.; 16 members and 13 guests were present and were welcomed. In the absence of the Secretary, Mr. Peter Dix read the minutes of the previous meeting, which were accepted as read. Dr. Klots proposed Miss Barbara Johnson of 418 Hicks Street, Brooklyn, a Biology Major of C.C.N.Y., for student membership.

Dr. Daniel Ludwig introduced the speaker of the evening, Mr. D. Robert Brebbia, who is one of his students at Fordham University and is now at the Rockland State Hospital Research Laboratory. He spoke on "Electrocardiographs of the Housefly." Mr. Brebbia reported that there is little knowledge of insect electrocardiographic behavior. The most complete study of this sort has been done on the grasshopper, *Melanoplus differen-*

tialis, and the cicada hearts. This work on the measurement of the action potential of the housefly heart should provide specific information concerning the action of ions on the cardiac muscle. This would aid in developing a satisfactory insect saline solution. Extracellular electrocardiographs were measured from *in situ* preparations of adult hearts by means of a glass, microcapillary electrode connected to a cathode ray oscilloscope through a pre-amplifier. The effects of various concentrations of sodium, potassium, and calcium ions on the electrocardiographs were determined by perfusion of a saline in which one ion concentration was varied, while the other two were maintained constant. Electrocardiographic tracings were photographed from the cathode ray screen. An analysis of the ECG in a normal perfusate indicates a rapid, diphasic action potential. However, this wave may be fractionated into a complex of three or more components by addition of cold saline. Gradations in spike height and duration occur during perfusion with varying concentrations of the individual ions, each ion producing a characteristic change in the electrical potential. Numerous electrocardiographs were shown, some magnified in time or fractionated to show small, superimposed potentials. The various ionic effects, differences in electrode placement, and other conditions were demonstrated and discussed. Many questions were asked during the discussion period.

The meeting adjourned at 9:45 P.M.

PETER H. DIX, ASST. SEC.

MEETING OF MARCH 7, 1961

The meeting was called to order by President Schmitt at 8:00 P.M. in Room 129 of the A. M. N. H. There were 32 members and four guests present. Mr. Dix read the minutes of the previous meeting which were accepted as read. Miss Barbara Johnson was elected to membership and Mr. Eugene T. McLaughlin and Mr. Louis M. Vasvary were proposed for membership. Miss Gray displayed a silver bracelet in the form of a spider and web and a piece of silk embroidered with silved sequins in the outline of a spider and web.

Dr. James Forbes then introduced the speaker of the evening, his colleague at Fordham University and our fellow-member, Dr. Louis S. Marks, who spoke on, "Polymorphism in the Genus *Papilio*." In his opening remarks he defined his terms and said he was going to share some of the perplexities of the subject with us. He started with Bates' study of polymorphism published in 1861 and led us to the present. He commented on the progress and the lack of it, the changes made in the subject, and the lack of experimental work on polymorphism in the past. Some of the aspects covered were sexual dimorphism, seasonal forms, mimicry, Mendelian relationships including some of the genetics, and various breeding experiments. This informative, technical talk was spiced with humor and barbed criticism, all of which was enthusiastically received. A lively discussion period followed.

The meeting adjourned at 9:45 P.M.

RAYMOND BRUSH, SECRETARY

MEETING OF MARCH 21, 1961

President Schmitt called the meeting to order at 8:05 P.M. in Room 129 of the A. M. N. H. Sixteen members and six guests were present and welcomed to the meeting. The minutes of the previous meeting were accepted as read. Mr. Eugene T. McLaughlin of Montclair State College and Mr. Louis M. Vasvary of the Entomology Department, Rutgers University, were elected to membership. It was announced that our Past-president, Mr. Shoumatoff, had received a new assignment and was moving to London, England. Dr. Schmitt suggested, since Mr. Shoumatoff was not present at this meeting, that a letter be sent to him praising him for his contributions to the Society and extending our very best wishes to him and his family. This was approved.

Dr. Schmitt then introduced Dr. Bailey B. Pepper, Chairman of the Department of Entomology at Rutgers, the State University at New Brunswick, New Jersey, who spoke on "Entomological Research In New Jersey." (An abstract follows). Many questions were asked of Dr. Pepper at the end of his talk. He distributed a pamphlet, "Entomology In New Jersey." Mrs. Patricia Vaurie had available for distribution several issues of the "Canadian Entomologist" which had accumulated in her office. The meeting adjourned at 9:45 P.M.

PETER H. DIX, ASST. SEC.

Entomological Research in New Jersey

The responsibilities of the Department of Entomology of Rutgers, The State University, are three-fold; research, teaching, and extension. It is almost impossible to separate these three activities. Extension usually considered as an extension of applied research and teaching, especially at the graduate level, involves research. The discussion, however, will be confined to the research aspects of the department.

Our permanent staff is composed of 22 members. Our graduate student enrollment for the current semester is 26. Every member of the staff is responsible to one or more research projects, and every staff member does some research, but every staff member does not necessarily have teaching responsibilities.

At the present time we have 38 projects. These projects range from applied to fundamental or basic research. Financial support for our projects includes state funds, through the New Jersey Agricultural Experiment Station; U.S. Department of Agriculture, administered through the Office of State Experiment Stations; other Federal agencies, such as the U. S. Public Health Service; endowments and industrial grants. Certain funds are allocated for specific purposes while the use of others is unrestricted. Our basic aims are to balance the type of research insofar as funds and source of funds permit. Our policy is to maintain, as far possible, a balance between taxonomic, morphological, biological, and physical and chemical research in our insect control programs as well as our teaching activities.

BAILEY B. PEPPER

**JOURNAL
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THE ABDOMINAL NERVOUS SYSTEM OF
PTERONARCYS (PLECOPTERA:
PTERONARCIDAE)¹

JOHN B. SCHMITT

RUTGERS—THE STATE UNIVERSITY
NEW BRUNSWICK, N. J.

RECEIVED FOR PUBLICATION JULY 24, 1962

ABSTRACT

The abdominal nervous system in the nymph of *Pteronarcys proteus* Newman, and in the adult of *P. californica* Newport is described. The ganglia of segments 3 and 4 are coalesced. The transverse nerves of segments 4, 5 and 6 arise from the ganglia of the immediately-following segments. Only the first three segments contain both dorsal and ventral nerves. The muscles and nerves of the genital segments are described.

Although the order Plecoptera is often referred to as an orthopteroid order, various writers (Snodgrass, 1936; Quadri, 1940) have shown that the external genitalia of both the male and the female insects are in no way generalized or orthopteroid. The original purpose of this study was to compare the abdominal nervous system in Plecoptera with the same system in Orthoptera (Schmitt, 1954), and also to determine whether the musculature and nervous system of the genital segments might provide clues helpful in establishing whether the absence of orthopteroid genitalia represents an ancestral condition.

The family Pteronarcide is usually described as one of the more generalized of Plecoptera, and the large size of species of the genus *Pteronarcys* make them especially attractive subjects for detailed studies on the nervous system. Nymphs of *Pteronarcys proteus* Newman were obtained from hillside streams in Warren County, New Jersey, through the courtesy of Dr. Lyle E. Hagmann. Unfortunately, no adults of this species could be found, and studies on adult *Pteronarcys* were made on specimens of *Pteronarcys californica* Newport, obtained from Messrs. Stanley G. Jewett, Jr. and William C. Crothers.

¹ Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers, The State University of New Jersey, Department of Entomology.

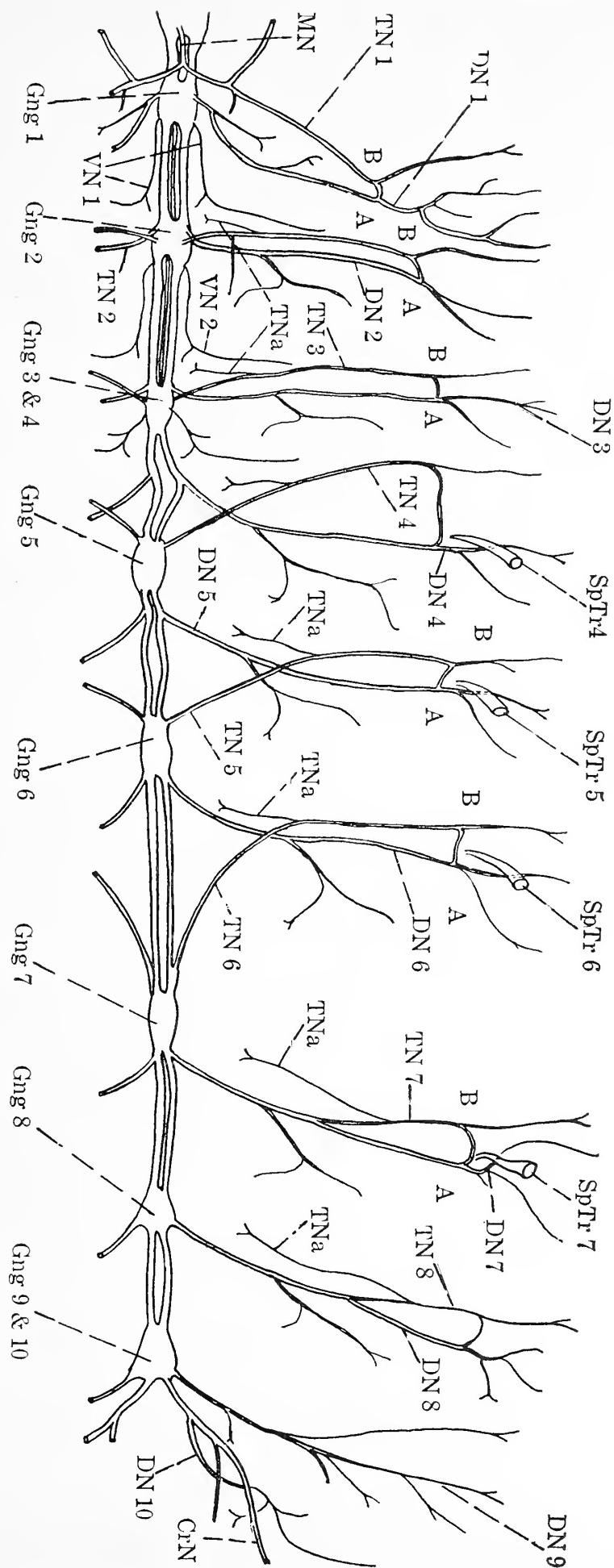


Fig. 1. The central nervous system of the abdomen of a full-grown nymph of *Pteronarcys proteus* Newman, showing the nerves of the right side.

THE VENTRAL NERVE CORD

The abdominal nerve cord of *Pteronarcys*, as noted by Newport (1851), apparently contains eight ganglia (Fig. 1). The terminal ganglion, however, provides nerves to the muscles of the ninth and tenth segments, and to the cerci. The muscles of the fourth segment are innervated by the branches of a pair of lateral nerves which appear to arise from the connection between the third and fourth definitive ganglia. The ganglion centers of these fourth segment nerves are contained in the third definitive ganglion, from which proceeds also the lateral nerves of the third segment. Thus at least ten segmental ganglia can be accounted for. Wittig (1955) found in *Perla abdominalis* Burm. a fusion of the ganglion of the first abdominal ganglion with the metathoracic ganglion, but in *Pteronarcys* the first ganglion remains separate.

A median or unpaired nerve extends posteriorly from the metathoracic ganglion in *Pteronarcys* and bifurcates to provide two lateral branches or transverse nerves (Fig. 1, *TN1*). These transverse nerves terminate in the alary muscles of the heart. An anterior branch of the first transverse nerve extending into the metathorax was not traced, but presumably is homologous with a similar branch described by Wittig in *Perla*.

The first abdominal ganglion gives off two pairs of lateral nerves. The anterior, more robust pair provides innervation to the muscles of the first abdominal segment. Since they terminate in the dorsal longitudinal muscles, this pair will be designated the dorsal nerve (*DN*), (Schmitt, 1954). A nerve joins the dorsal nerve and the transverse nerve at the position A-B. This nerve connection, A-B, resembles a similar connection found by the writer in the pregenital abdominal segments of certain Orthoptera (Schmitt, 1954), and by Maki (1936) in a neuroppteran, *Chauliodes*, which will be discussed later in greater detail. From this nerve connection in the Orthoptera, proceeds the innervation of the dilator and occlusor muscles of the spiracle, but no such muscles could be found in *Pteronarcys*. In *Perla* Wittig (1955) found not a perceptible nerve connection A-B but a union of the transverse nerve (III N10) and the dorsal nerve (III N8).

A second, weak nerve (Fig. 1, *VN1*) leaves the first abdominal ganglion behind the dorsal nerve and proceeds posteriorly along

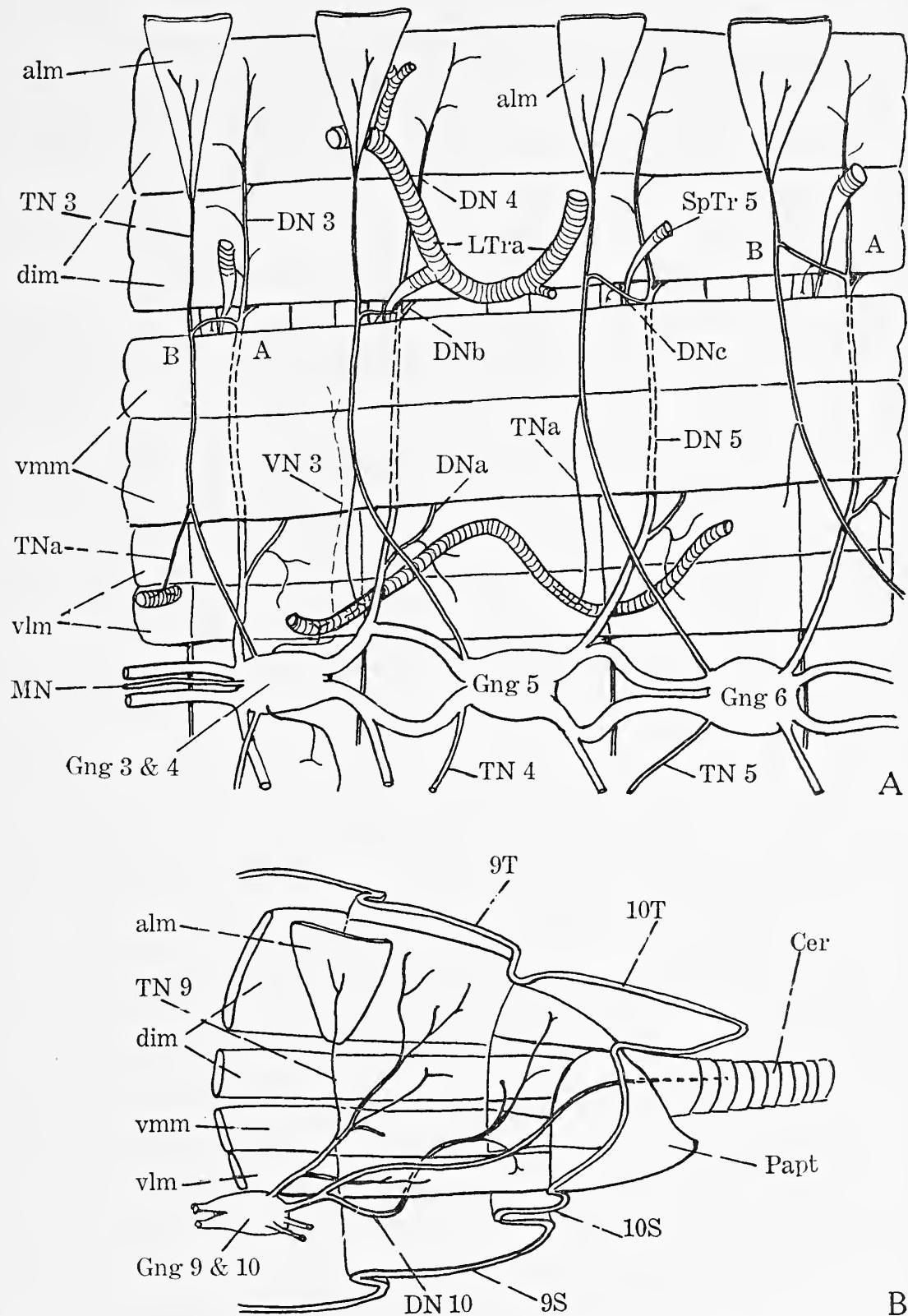


Fig. 2. Structures of the nymph of *Pteronarcys proteus*. A. Muscles, ganglia and nerves of the right side of abdominal segments 3, 4, 5 and 6 viewed mesally. B. Muscles, ganglion and nerves in the right side of the terminal part of the abdomen, viewed mesally.

the ventral tracheal trunk which parallels the ventral nerve cord. After giving off fine branches to this tracheal trunk, the nerve passes laterally and dorsally along the integument, laterad of the segmental muscles, but not providing any innervation to them. It is probably homologous with the "ventral nerve" described by the writer in Orthoptera (Schmitt, 1954, 1962), but the absence of any muscle innervations leaves this uncertain. Wittig (1955) describes in *Perla* a nerve of the first abdominal segment, III N9, which appears to be the same nerve, and says of it that it perhaps innervates the lateral muscles of the first abdominal segment.

The second abdominal ganglion in *Pteronarcys* gives off three pairs of nerves. One pair of these are the dorsal nerves (*DN*2). A second much finer pair, which arises posteriorly and somewhat more medially from the ganglion, are the transverse nerves of the second segment. These nerves terminate in the alary muscles of the heart and are connected to the dorsal nerve by the fine connection (A-B) previously described in the first abdominal segment. A fine branch, *TNa*, leaves the transverse nerve ventrad to the point "B" and innervates the ventral longitudinal tracheal trunk. A median nerve extends between the first and second ganglia, but gives off no branches. A pair of ventral nerves resembling those of the first abdominal ganglion makes up the third pair of nerves.

The nerves of the third abdominal segment resemble superficially at least those of the second. (Figs. 1, 2A) A pair of dorsal nerves arises from the anterior-lateral corners of the ganglion or, less frequently from the interganglionic connective, at a point just anterior to the third ganglion. An unbranched median nerve extends between the second and the third ganglia, but the transverse nerves, which may be recognized by such criteria as the connection A-B with the dorsal nerve, innervation of the ventral longitudinal tracheal trunk, and innervation of the alary muscles, arise from the third ganglion posteriorly to the dorsal nerves. The third pair of nerves, presumably the ventral nerves, is very fine and weak. All ganglia posterior to the third lack the ventral nerves.

As previously noted, the dorsal nerves of the fourth abdominal segment appear to arise from the interganglionic connective, usually at a point somewhere between one quarter and one half

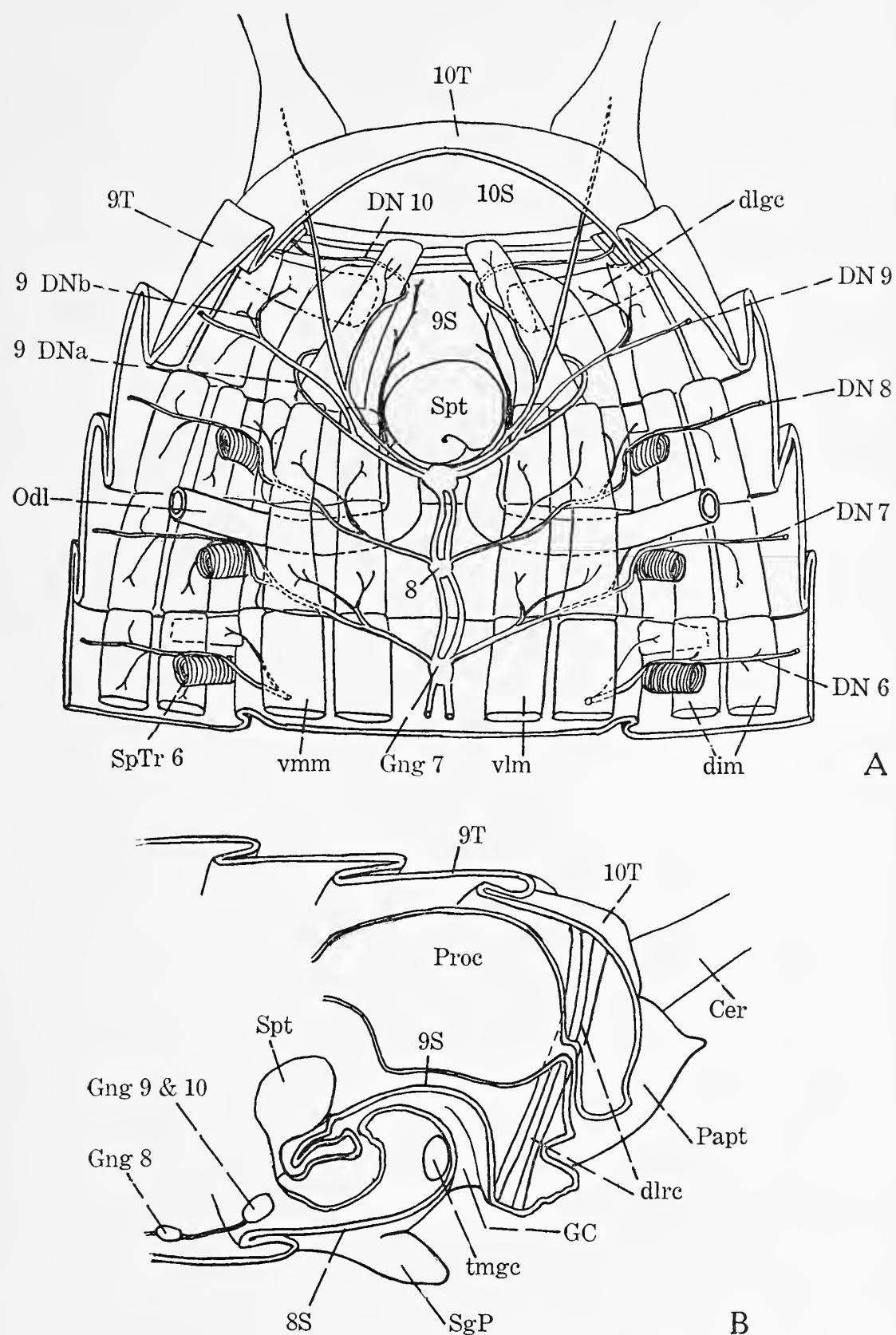


Fig. 3. Structures of the female of *Pteronarcys californica* Newport.
 A. Internal genitalia, nerves and muscles of the terminal part of the abdomen.
 B. Right half of the terminal part of the abdomen.

of the interganglionic distance. Paraffin sections of the third definite ganglion, cut longitudinally, indicated that the ganglionic center of the fourth abdominal segment is contained in the third ganglionic mass. The transverse nerves of the fourth segment, however, arise from the next ganglion, pass anteriorly, crossing mesally the dorsal nerves of the fourth segment, and rise to terminate in the alary muscles of the heart arising on the antecostal ridge between the third and fourth segments. The identity of the transverse nerves is further confirmed by the connection A-B, and by the branch TNa to the ventral longitudinal tracheal trunk, as in the anterior segments. The writer has no explanation to account for the fact that the transverse nerve of the fourth segment is associated with the ganglion of the fifth abdominal segment.

The transverse nerves of the fifth and the sixth abdominal segments present the same anomaly. (Figs. 1, 2A) In both of these segments, their transverse nerves arise from the ganglion of the respectively immediately-posterior segment. It might be suggested that the actual roots of the nerves are in a more anterior ganglion, and the axons simply pass posteriorly along the interganglionic connectives to the ganglion of seeming origin. This possibility, however, does not explain what advantage there is to the insect in such an arrangement, which presumably is assumed post-embryonically.

The ganglion of the seventh abdominal segment of *Pteronarcys* appears as a result to be the source of two pairs of transverse nerves. (Fig. 1). Those of the seventh segment are fused with the dorsal nerves as they leave the ganglion, but their identity is easily established by the criteria already enumerated. The innervation pattern of the eighth segment resembles closely that of the seventh segment. The terminal ganglion provides nerves to the ninth and tenth segments and to the cerci, and will be described in greater detail in dealing with the genital segments.

THE PREGENITAL SEGMENTAL MUSCULATURE AND INNERVATION

Maki (1938) and Ford (1923) reported on the musculature of the abdomen in the Plecoptera, and Wittig (1955), in her study of the thorax of *Perla*, provides some information on the first abdominal segment. All three papers, however, deal with species in the family Perlidae, and there appear to be no previous reports on the abdominal musculature in the Pteronarcidae.

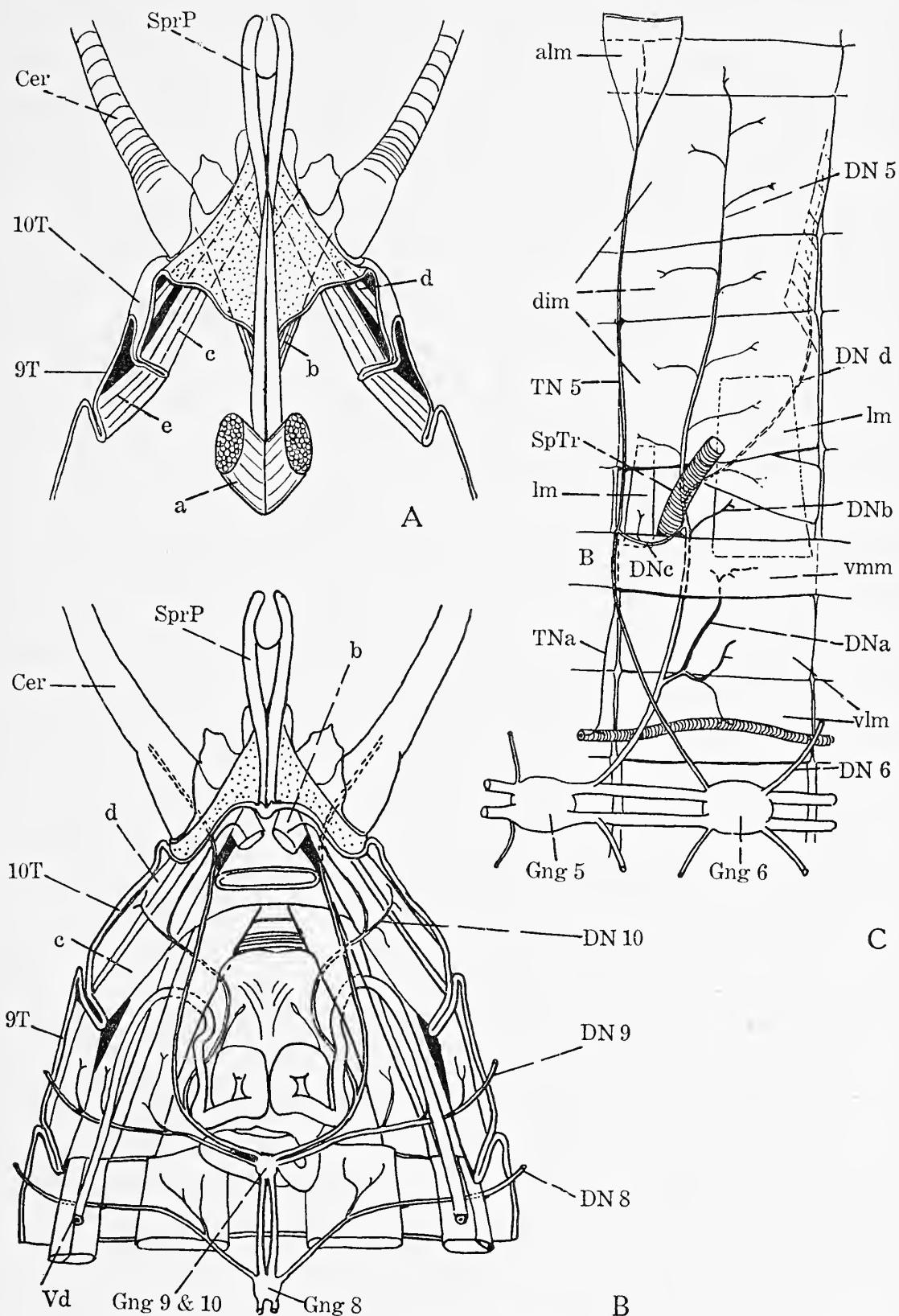


Fig. 4. Structures of the male of *Pteronarcys californica*. A. Dorsal view of supra anal plate, showing muscles and associated structures. B. Internal genitalia, nerves and muscles of the terminal part of the abdomen. C. Nerves and muscles of the right side of segment 5, viewed mesally.

In the studies reported on herein, dissections were first made on large nymphs of *Pteronarcys proteus* Newman and then repeated on adults of *Pteronarcys pacifica* Newport. The differences between nymph and adult were very slight, and involved chiefly a lesser degree of development of the tergo-sternal muscles in the nymph. The musculature arrangements reported by Maki and by Ford closely agree, with a few minor exceptions to be noted, with *Pteronarcys*.

The longitudinal muscles, both dorsal and ventral, are very strongly developed in both nymph and adult of *Pteronarcys*. Both Maki and Ford describe two pairs of ventral longitudinal muscles, one pair extending from one intersegmental ridge to the next, and a second pair arising posteriorly on the sternum and inserting on the intersegmental ridge. This second pair is absent in *Pteronarcys*. The ventral muscles in *Pteronarcys*, however, are divided by dorsal nerve into two bundles, a lateral ventral bundle (Fig. 2A, *vlm*) laterad of the dorsal nerve, and a median ventral muscle (Fig. 2A, *vmm*). The lateral ventral bundle is a broad, flat series, with most of the fibres attached at the intersegmental ridge. The median ventral muscle is, in the anterior segments, a thicker, more rounded group, which diminishes in prominence in the posterior segments. Only the more lateral fibres are attached at the intersegmental lines in the anterior segments. In the first abdominal segment, however, the dorsal nerve passes laterad of all ventral longitudinal muscles.

The dorsal longitudinal muscles are also strongly developed in both nymph and adult. There is some tendency of the fibres to form two bands of approximately equal width, but apart from this, grouping of the fibres is very variable. They may be designated the "internal dorsal muscles" (Fig. 2A, *dim*). Much less prominent are two pairs of external dorsal muscles which can be made visible only by removal of the internal dorsal muscles.

The tergosternal or lateral muscles are poorly developed in *Pteronarcys*, compared with the findings of Ford and Maki, and only two pairs may be recognized in each segment. These muscles have the position of external laterals, and are better developed in the adult than in the nymph. (Fig. 4C, *lm*). No occlusor or dilator muscles of the spiracles could be found in *Pteronarcys*, although both Maki and Ford describe such muscles in the Perlidae.

The nymphs of *Pteronarcys* contain rather prominent dorsal transverse or alary muscles, arising on the intersegmental ridges and attaching laterally on the dorsal vessel. (Fig. 2A, *alm*). In the adult, and especially in the female, these muscles are much less obvious.

The innervation of the muscles of several pregenital segments of the nymph is illustrated in Fig. 2A, and the fifth segment of the adult in Fig. 4C. Both figures show the right side only. Proceeding from the ganglion along the dorsal nerve, one finds first a conspicuous branch, *DNa*, innervating the ventral longitudinal muscles. The finer branches may be traced along the mesal surface of the ventral lateral muscle, *vlm*, and between these fibres and the ventral median muscle, *vmm*. The second branch of the dorsal nerve, *DNb*, leaves the main nerve near the dorsal edge of the ventral longitudinal muscles and innervates the external lateral muscles.

A third branch, *DNc*, leaves the dorsal nerve passing anteriorly, below the spiracular trachea, and joins the transverse nerve to form the nerve loop A-B, which resembles a similarly-situated loop in certain Orthoptera (Marquardt, 1939; Schmitt, 1954), in the cecropia moth (Beckel, 1958; Libby, 1959, 1961), and in the neuropterous insect, *Chauliodes* (Maki, 1936). In all of these insects, the nerves to the spiracular muscles arise from this dorsal nerve-transverse nerve loop, and it is unfortunate that spiracular muscles could not be found in *Pteronarcys*. In the segments which contain a tergosternal muscle anterior to the spiracular trachea, a fine branch from *DNc* provides innervation to those fibres.

Innervation of the external dorsal muscles arises from the remaining branches of the dorsal nerve. An anterior branch of the dorsal nerve enters the integument. The main part of the dorsal nerve passes laterad of the lateral longitudinal tracheal trunk.

THE GENITAL AND POSTGENITAL SEGMENTS

The muscles and nerves of the posterior segments of the abdomen of the *Pteronarcys* nymph are represented in Fig. 2B. The last alary muscles of the heart arise on the intersegmental ridge between the eighth and the ninth segments and the fine nerves to these muscles are, presumably, the transverse nerves.

The more median of the ventral longitudinal muscles of the ninth segment lacks a posterior attachment and is continuous with the corresponding muscle of the tenth segment. A similar fusion of the ventral internal longitudinal muscles of segments nine and ten has been described in the Orthoptera by Ander (1939) and in other Plecoptera by Brink (1956). Innervation of the fused muscles in *Pteronarcys* is provided by branches from both the ninth and the tenth dorsal nerves. The dorsal nerves of the tenth segment pass laterad of the fused ventral longitudinal muscles, but the nerves which enter the cerci and the paraprocts remain medial in position. Branches from the dorsal nerves of both the ninth and the tenth segments innervate the dilator muscles of the rectum.

THE MALE

The male genitalia of *Pteronarcys* have been described by Smith (1917) and by Snodgrass (1936). Brink (1956) provides an excellent review of the literature on the reproductive system and the genitalia in the Plecoptera. The arrangement of muscles and nerves in the male of *Pteronarcys pacifica* is shown in Figure 4, A,B. The most prominent feature of the male genitalia is the median supra anal plate or process (*SprP*). Three pairs of muscles were found to be inserted on this structure, although Smith (1917) illustrates only a single pair. The precise functions of these muscles probably should be described from observations on live stoneflies but as none were available these muscles will merely be designated by letters. The pair of muscles designated by the letter *a* arise on the ninth tergum and insert on the anterior end of the supra anal process. These muscles are short and very stout. A second pair of muscles, *b*, extend from the supra anal process to the tenth segment, being attached immediately beneath the cerci. The tenth segment is divided in *Pteronarcys pacifica* into a dorsal portion, bearing the genital lobes or tergal processes, and a ventral arch, from which the cerci arise. The ventral arch becomes very narrow medially, where the ventral longitudinal muscles are inserted. A third pair of large muscles, *c*, arise on the anterior phragma of the tenth segment and insert on the supra and process immediately posterior to muscle *b*. A fourth pair of tergal muscles, *d*, arise on the anterior phragma of the tenth segment, laterad of muscle *c* and

insert on the ventral ring of the tenth segment, just anterior to the cerci. Mention should also be made of a fifth pair of muscles of tergal muscles, *e*, which are aligned with muscle *c*, and extend between the phragma at each end of segment nine.

The ventral musculature of segments nine and ten is also shown in Fig. 4B. The median pair are the fused muscles of segments nine and ten previously described from the nymph. The lateral pair of ventral muscles of the ninth segment show almost no change from the corresponding muscles in the nymph. The median pair of ventral longitudinal muscles in segment eight are broad flat sheets of muscles which serve to retract the subgenital plate or ninth sternum and thus expose more fully the orifice of the genital cavity.

The vasa deferentia (*Vd*) in *Pteronarcys* are much coiled in the posterior segments, but ultimately they may be traced to the positions shown in Fig. 4B. It is interesting to note that to reach a median position they pass beneath the fused ventral longitudinal muscles, as has been described in Orthoptera and Thysanura by Ander (1939) and in other Plecoptera by Brink (1956).

Despite the seeming complexity of the male genital structures, the nervous system in the genital region shows very little change from the nymph. The dorsal nerves of the ninth segment pass beneath or laterad of the vasa deferentia and terminate in the large tergal muscles *a*. The nerves of the tenth segment pass beneath the vasa deferentia and, as in the nymph, beneath the fused ventral longitudinal muscles but above the lateral pair of ventral longitudinals. After innervating the fused muscles, it provides nerves to muscles *c* and *d*, and a branch reaches muscle *b* by a posterior extension. The nerves of the cerci, after leaving their common roots with the tenth segment nerves, pass posteriorly along the dorsal surface of the fused ventral longitudinal muscles, as in the nymph, and in so doing, pass above the vasa deferentia. Brink (1956) has already observed this arrangement in other Plecoptera. As is well known, Snodgrass (1936) has interpreted this nerve-gonoduct relationship as evidence that primitive genital ducts turned downward to the body wall between the nerves of the tenth and the eleventh abdominal segments, and, further, that the cerci are appendages of the eleventh abdominal segment.

THE FEMALE

As in the case of the male, it may be said that the genital structures of the female are developed with surprisingly little change from the fundamental features of the nymph. Fig. 3A presents a ventral view of the genital segments of the female of *Pteronarcys pacifica*. As shown by Quadri (1940), the eighth sternum bears posteriorly a pair of sclerotized processes, the subgenital plates, (Fig. 3B, *SgP*) having no associated musculature. A deeply invaginated transverse genital cleft, involving the remainder of the eighth sternum and a large part of the ninth sternum, immediately follows. A transverse muscle arises on the posterior lateral edges of the eighth sternum and is thus contained within the inflexed part of the eighth sternum (Fig. 3B, *tmgc*). The sclerotized parts of the ninth sternum consist of a narrow transverse piece forming the posterior edge of the genital cleft, and a pair of triangular sclerites on either side of the genital cleft, on each of which is inserted a large tergo-sternal muscle, the dilator of the genital cleft. (Fig. 3A, *dlgc*). The tenth sternum is represented by a narrow sclerite.

The arrangement of nerves, muscles, and certain other internal structures of the female is shown in Fig 3A. The muscles of the seventh segment do not differ significantly from those of the nymph. The lateral oviducts lead to the short median oviduct by passing ventrad of the ventral longitudinal muscles of the seventh segment, as has been described in Orthoptera by Ander (1939) and in Plecoptera by Brink (1956). The eighth segment presents no marked change from the nymph, other than the development of the transverse muscle of the genital cleft. (Fig. 3B, *tmgc*). In the ninth segment, the most conspicuous change is the enlargement of the tergosternal muscles to become the dilators of the genital cleft (*dlgc*). As in the nymph the median pair of ventral longitudinal muscles of the ninth segment is fused with those of the tenth. The dilators of the rectum are well developed and extend as an almost continuous band between the tergum and sternum of the tenth segment. In view of the relatively smaller diameter of the rectum in the area of attachment, it is more likely that the contraction of these muscles serves to draw up the sternum and thereby increase the opening of the genital cleft.

As may be seen in Fig. 3A, the nerves of the seventh seg-

ment of the adult do not differ from those of the nymph. The eighth segment nerves provide a branch which passes ventrally beneath the ventral longitudinal muscles and innervates the transverse muscle of the genital cleft. The nerves of the ninth segment and the last nerves, containing the fused nerves of the tenth segment and the cerci leave the terminal ganglion separately but in close proximity. The first branches of the nerves of the ninth segment ($9DN_a$) innervate the median pair of ventral longitudinal muscles, and the second ($9DN_b$) innervate the dilators of the genital cleft and the lower bands of the dorsal longitudinal muscles. The last pair of nerves in the female provides first, on each side, a branch to the ninth sternum, which is hardly to be expected if this pair represents nerve elements of the tenth and eleventh segments only. Just beyond the branches to the ninth sternum, the nerves of the tenth segment separate from the cercal nerves, innervate and pass beneath the median pair of ventral longitudinal muscles, and then follow the body contours to reach the very short dorsal muscles. A branch of this nerve provides innervation of the dilators of the rectum.

DISCUSSION

The abdominal musculature of nymphs of *Pteronarcys proteus* Newman serves primarily to produce vigorous sideways movements of the abdomen which propel the insect through the water, and consists almost exclusively of longitudinal muscles. The musculature of the adult insect is inherited directly from the nymph, but without adding any special features for its existence. Thus it is the requirements of the aquatic environment which have governed the plan of musculature in *Pteronarcys*.

The segmental nerve plan in *Pteronarcys* is much reduced, as compared with that of the Orthoptera. The dorsal nerve is highly developed, but the ventral nerve is much reduced and is found only in the first three segments. The most remarkable feature of the abdominal nervous system in *Pteronarcys* is undoubtedly the posterior transposition of the apparent origin of the transverse nerves in segments four, five, and six, to the ganglia of the immediately-posterior segments. Newport's Plate 21, figure 14, reveals that he observed this phenomenon as

regards segments four and five, but apparently failed to note that the transverse nerves cross over rather than fuse with the dorsal nerves. It now becomes of interest to discover how extensively this exists in the Plecoptera, and also how it comes about.

The musculature and nervous system of the genital segments provides nothing to suggest that any ancestor of *Pteronarcys* possessed essentially orthopteroid genitalia. Probably the most interesting feature of the internal anatomy of the genital segments is the absence, in both sexes, of elaborate systems of muscles and nerves, the needs of both sexes being served with surprisingly little modification of the nymphal condition.

Key to figure abbreviations

- alm, alary muscle
- Cer, cerus
- Crn, cercal nerve
- dim, dorsal internal muscle
- dlge, dilator of the genital cleft
- dlrc, dilator of the rectum
- DN, dorsal nerve
- DN1, DN2, etc., dorsal nerve of the indicated segment
- DNa, DNb, etc., branches of the dorsal nerve
- GC, genital cleft
- Gng 1, Gng 2, etc., ganglion of the indicated segment
- lm, lateral muscle
- LTra, lateral tracheal trunk
- MN, median nerve
- Odl, lateral oviduct
- Papt, paraproct
- Proc, proctodaeum
- 8S, 9S, etc., sternum of the indicated segment
- SgP, subgenital plate
- SprP, supra anal plate
- Spt, spermatheca
- Sp Tr 4, SP Tr 5, etc., spiracular trachea of the indicated segment
- 8T, 9T, etc., tergum of the indicated segment
- tmgc, transverse muscle of the genital cavity
- TN 1, TN 2, etc., transverse nerve of the indicated segment

TNa, branch of transverse nerve to the ventral tracheal trunk

Vd, vas deferens

vlm, lateral ventral muscle

vmm, median ventral muscle

VN1, VN2, etc., ventral nerve of the indicated segment

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ANOTHER RECORD OF TABANIDAE AS PREY
OF *CRABRO MONTICOLA* (PACKARD)
(HYMENOPTERA: SPHECIDAE)

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ABSTRACT

The taking of Tabanidae as prey by the wasp *Crabro monticola* is confirmed. *Chrysops venus* is added to the previously known species used as prey.

Evans (1960) reported four species of Tabanidae as prey of *Crabro monticola* (Packard). In 1961 I made some casual observations on this wasp and added one more species of Tabanidae used as prey.

Four nests were found in an area of two square feet in the center of a lightly traveled gravel road about two miles south of Seguin Falls, Parry Sound District, Ontario. The external appearance of the nests was similar to the description given by Evans.

The wasps approached the nests flying very slowly, probably due to the weight of the prey. If disturbed in any way, either in the air or on the ground, they immediately dropped the prey and flew away. All collections were made from wasps approaching the nests. Two wasps were collected to secure identification which was made by Dr. Karl V. Krombein.

On July 29, three male specimens of *Stonemyia tranquilla* (O.S.) were secured; on August 1, one male of *S. tranquilla* and one female of *Chrysops venus* Philip; on August 4, one male of *S. tranquilla*.

All collections were made in the morning. Continuous observations were not possible but it was noted that openings to all nests were closed in the afternoon and no wasps were about. The wasp carrying the specimen of *C. venus* flew more rapidly than those with *S. tranquilla* probably due to the smaller size of this species. *C. venus* has not previously been reported as prey of *Crabro monticola*.

It is of interest that the most common prey, *S. tranquilla*, was also reported by Evans as prey of *Crabro monticola* at Mt. Desert Island, Maine some 12 degrees east and one degree south of Seguin Falls. His specimens were also all males. Dr. Henry

Dietrich, who collected the Mt. Desert Island material, informs me that he was unable to collect *S. tranquilla* in the field at that time. The writer had the same experience although he has collected this species in this area in previous years.

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POPULATION CHARACTERISTICS AMONG COLONIES OF THE ANT *FORMICA OPACIVENTRIS* EMERY¹ (HYMENOPTERA: FORMICIDAE)

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ABSTRACT

Population characteristics are described for approximately 400 mound nests of *Formica opaciventris* censused over a 3 year period in Wyoming. During this period of observation, density remained stable at 0.007 nests/sq. meter with a maximum density of 0.4 nests/sq. meter.

Mounds are categorized into size and activity classes and yearly changes are noted. Only a portion of the population releases sexuals, and on a statistical basis these fertile mounds are more likely to be found among the larger, more active segment of the population, and in the NW quadrant of this study area.

Mortality rate for the total population was 8%-9%, increasing regularly at lower activity levels. Nest birth rate was 5%-13% during the period of observation. These rates are compared with those of closely related species of *Formica*.

Population characteristics of social insects are of especial interest since these populations operate simultaneously at the level of

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the colony, the population of colonies, and the interspecies population of colonies, and can be investigated at each of these levels of integration. This report contains an examination and description of a population of the mound building ant *Formica opaciventris* Emery at the intraspecies population of colonies level, and it follows an earlier description of colony life history, nest structure and reproductive behavior in this species (Scherba, 1961).

Several different aspects of the population of colonies of ants have been investigated by zoologists over the years. Population of colonies densities have been measured, usually by a quadrat sampling technique, by Brian (1951, 1952), Headley (1949, 1952), and Talbot (1953). An interesting aerial estimate of *Pogonomyrmex* density is reported by Weber (1959). In general,

TABLE I
HIGH POPULATION OF COLONY DENSITIES
FROM VARIOUS COMMUNITIES

Species	Nest per Square Meter	Square Meters Per Nest	Source
<i>Ponera c. pennsylvanica</i>	9.1	0.1	Headley (1952)
<i>Myrmica rubra macrogyna</i>	3.1	0.3	Brian (1951)
<i>Aphaenogaster rudis</i>	1.9	0.5	Talbot (1957)
<i>Lasius niger neoniger</i>	0.5	2.0	Talbot (1953)
<i>Aphaenogaster fulva aquia</i>	0.1	8.8	Headley (1949)
<i>Formica opaciventris</i> (maximum density)	0.04	24.4	Present study
<i>Formica ulkei</i>	0.02	47.2	Dreyer (1942)
<i>Formica exsectoides</i>	0.01	69.0	Andrews (1925)

species with high intranest densities seem to have lower population of colony densities in the habitats examined (Table I).

Measurements of density changes over a period of years have been reported for *Formica exsectoides* (Andrews, 1925, 1926; Cory and Haviland, 1938; Haviland, 1948), *Formica ulkei* (Dreyer and Park, 1932; Dreyer, 1942; Scherba, 1958; Talbot, 1961) and *Formica obscuripes* (King and Sallee, 1953, 1956). Some of the censuses span an impressive length of time: 9 years for the *F. obscuripes* population in Iowa, 15 years for the *F. exsectoides* population near Baltimore; 23 years for the *F. ulkei* population southwest of Chicago, and 48 years for the *F. exsectoides* population near Altoona, Pennsylvania.

Changes in the proportion of mound nests of different sizes

with time have been included in some of the reports cited above. In each instance there was a definite trend toward the decrease in proportion of small mounds and corresponding increase in proportion of larger nests (Andrews, 1926; Dreyer, 1942; Scherba, 1958; Talbot, 1961).

Information about nest birth rate, the number of new colonies expressed as a proportion of existing colonies, has been reported for *F. ulkei* and *F. obscuripes*. The mean for two established populations was approximately 12.5%, while in a new and rapidly expanding population nest birth rate rose to 57.2% and then declined as the habitat stabilized (King and Sallee, 1953, 1956; Scherba, 1958; Talbot, 1961). Death rate, expressed here as the proportion of the population of a particular year which dies in each succeeding year, was 4.5% in the *F. exsectoides* population reported by Haviland (1948), approximately 9% in that reported by Andrews (1926), approximately 6% in the *F. ulkei* population reported by Dreyer (1942), approximately 9% for the same population at a later date (Scherba, 1958), and approximately 17% for the *F. obscuripes* population observed by King and Sallee (1953, 1956). Although both Scherba (1958) and Talbot (1961) report that death rate was higher among new nests than established nests, the opposite was reported for the *F. obscuripes* population followed by King and Sallee.

The re-entry of fecundated females into established nests in several species of *Formica* would be expected to render these colonies immortal, but this appears to be not the case, although data on longevity of colonies is scanty. Dreyer (1942) has estimated the longevity of *F. ulkei* at 20–25 years, and King and Sallee (1953, 1956) have calculated the half-life, that point in time on a modified survivorship curve at which the mixed-age population of a particular year has declined by one-half, for the populations mentioned.

Regulation of colony density, where investigated, involves interaction of physical environmental factors (Cole, 1934) with competition for food and nesting sites (Brian, 1952, 1952a, 1956; Pontin, 1961) and territoriality (Brian, 1955).

It is important to note that most of the longer-term population of colonies investigations have been conducted upon the long-lived, conspicuous mound nests of *Formica* species, especially those of the *exsecta* group. This has the advantage of permitting

comparisons among the several populations examined, but also invites caution in extending expectations to other groups of ants.

THE POPULATION

The population examined in this report is located on Moose Island, a small island in the Snake River, one mile east of Jackson Lake, in western Wyoming. The site is at an elevation of 6775 feet. The conspicuous mound nests of this population occupy the central Silver Sagebrush (*Artemisia cana*) meadow and are entirely restricted to this meadow.

Formica opaciventris is one of three North American species in the *exsecta* group of *Formica*, together with *ulkei* and *exsectoides*, mentioned above. Characteristics of this population with respect to density, composition, birth rate, and death rate are described below.

METHODS

A total census of the number of *opaciventris* mounds on Moose Island was recorded during July and August, 1957, 1958, and 1959. After the meadow was carefully mapped and its boundaries delineated, the location of each *opaciventris* mound was noted on the map and a numbered survey stake was erected next to each mound.

At each mound, the length of the longest basal diameter, in inches, was measured in 1957 and 1959, as an index of mound size. For purposes of tabulation, mounds are classified into three size groups, following the scheme of Dreyer and Park (1932); small mounds < 24 inches; medium mounds 24 to 47 inches; large mounds > 48 inches. The size of a small number of mounds was not measured because of indefinite boundaries in certain incipient and moribund nests, and because of oversight in others. These mounds are listed as unclassified (Table 2).

In 1957, 1958, and 1959, an estimate of the level of activity of the inhabitants of each mound was recorded by reference to the following criteria: level 4—workers abundant and active, mound surface soil freshly mined overall, vegetation absent from apical area of mound; level 3—workers abundant and active, mound surface soil freshly mined overall but with some vegetation on apical mound area; level 2—workers active, mound surface with little freshly mined soil, vegetation present on apical mound area as well as on other portions of mound surface; level 1

—workers sparse, mound surface dried, cracked, with little or no mined soil, vegetation abundant on surface. The activity classes so defined are assumed to be correlated with the density and vigor of the worker population inhabiting each mound. Although there is no difficulty in assigning activity levels consistently to active mounds, it has not been possible to consistently state with certainty that a formerly inhabited mound is now

TABLE II
FORMICA OPACIVENTRIS, NESTS CLASSIFIED BY SIZE
AND ACTIVITY, JULY-AUGUST 1957, 1958 AND 1959

Activity Level*	Activity Classes					
	1957		1958		1959	
	n	%	n	%	n	%
0	11	2.57	15	3.77	10	2.39
1	69	16.12	49	12.31	41	9.79
2	82	19.16	84	21.11	117	27.92
3	115	26.87	120	30.15	174	41.53
4	140	32.71	126	31.66	75	17.90
unclassified	11	2.57	4	1.00	2	0.48
	428		398		419	

Size Classes**	Size Classes					
	1957		1958		1959	
	n	%	n	%	n	%
Unclassified	58	13.55		not measured	126	30.07
Small	315	73.60			244	58.23
Medium	44	10.28			44	10.50
Large	11	2.57			5	1.19
	428				419	

* See text for explanation of categories.

** Size Classes: Small = < 24 inches; Medium = 24–47 inches; Large = > 48 inches.

abandoned and a dead nest. For these cases of apparently moribund mounds, which may actually be dead nests, level 0 is assigned. A small number of mounds were not classified as to activity level for the reasons stated above and these nests are tabulated as Unclassified (Table II).

POPULATION STRUCTURE

Density In 1957 there were 428 mound nests of *F. opaciventris* distributed on the silver sage meadow with an overall density of one mound/147.2 square meters (0.007 nest/square meter),

and a maximum density of one mound/23.7 square meters (Table I). Size of the mound population remained at approximately 400 nests during the three seasons of observation and varied by less than 10% from year to year (Table II and Fig. 1).

Size class changes In both 1957 and 1959 medium mounds were the most abundant, large mounds the least (Fig. 2). Between 1957 and 1959 changes in mound size and the founding of new, small nests resulted in an increased proportion of small and a decreased proportion of medium mounds. Rate of change from one size class to another was approximately 18% for me-

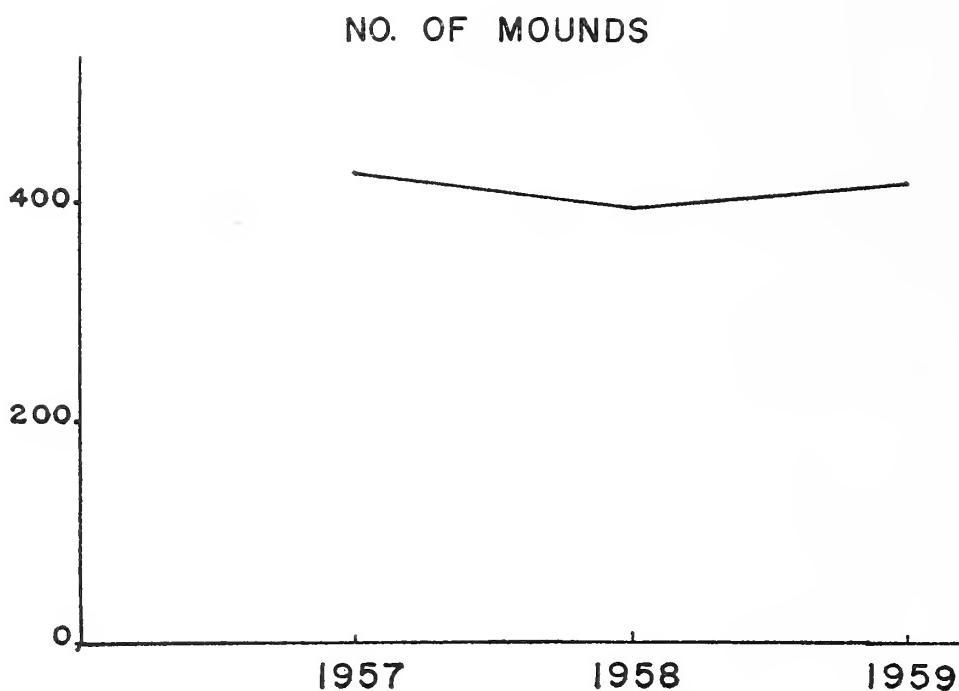


Figure 1 Change in total size of population of colonies during the 3 year period of census.

dium and large mounds, 9% for small mounds. Of the 70 size class changes recorded from classified mounds, 16 increased in size class and 54 decreased in size class over the two-year period.

Activity level The proportion of mounds at each activity level was similar in 1957 and 1958, then changed markedly in 1959. During 1957 and 1958, the population of mounds comprised 31%-33% level 4; 27%-30% level 3; 19%-21% level 2; 12%-16% level 1, and 2%-4% level 0 mounds (Fig. 3).

Changes in activity level from one level to another occurred among 48.4% of the 1957 population and 44.2% of the 1958 population. These changes did not occur with equal frequency

at each activity level; instead there appears to be a gradation in stability such that a larger proportion of the level 0 mounds changed levels each year, with the proportion decreasing at each level to level 4, with the exception of the level 4 changes in 1959 (Table III).

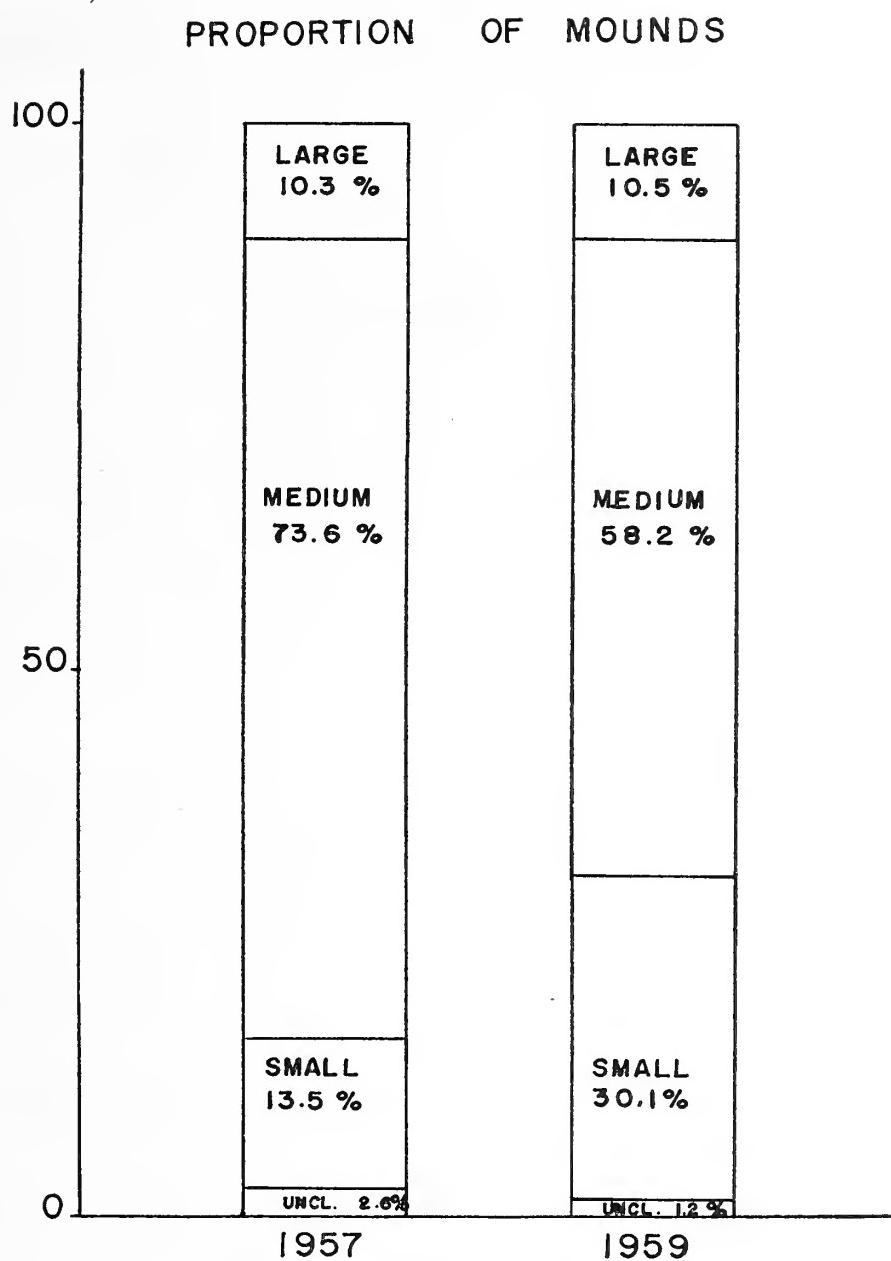


Figure 2 Proportion of mounds in percent at each size class in 1957 and 1959.

The following changes in the proportion of mounds at each activity level occurred between 1957 and 1959. A gradual decrease in level 1 mounds from 16.0% to 9.7%; an increase in level 2 mounds from 19.2% to 27.9%; a marked increase in level

3 mounds from 26.9% to 41.5%; a marked decrease in level 4 mounds from 32.7% to 17.9%.

At present, we are unable to account for most of the observed changes on the basis of external environmental factors. A pos-

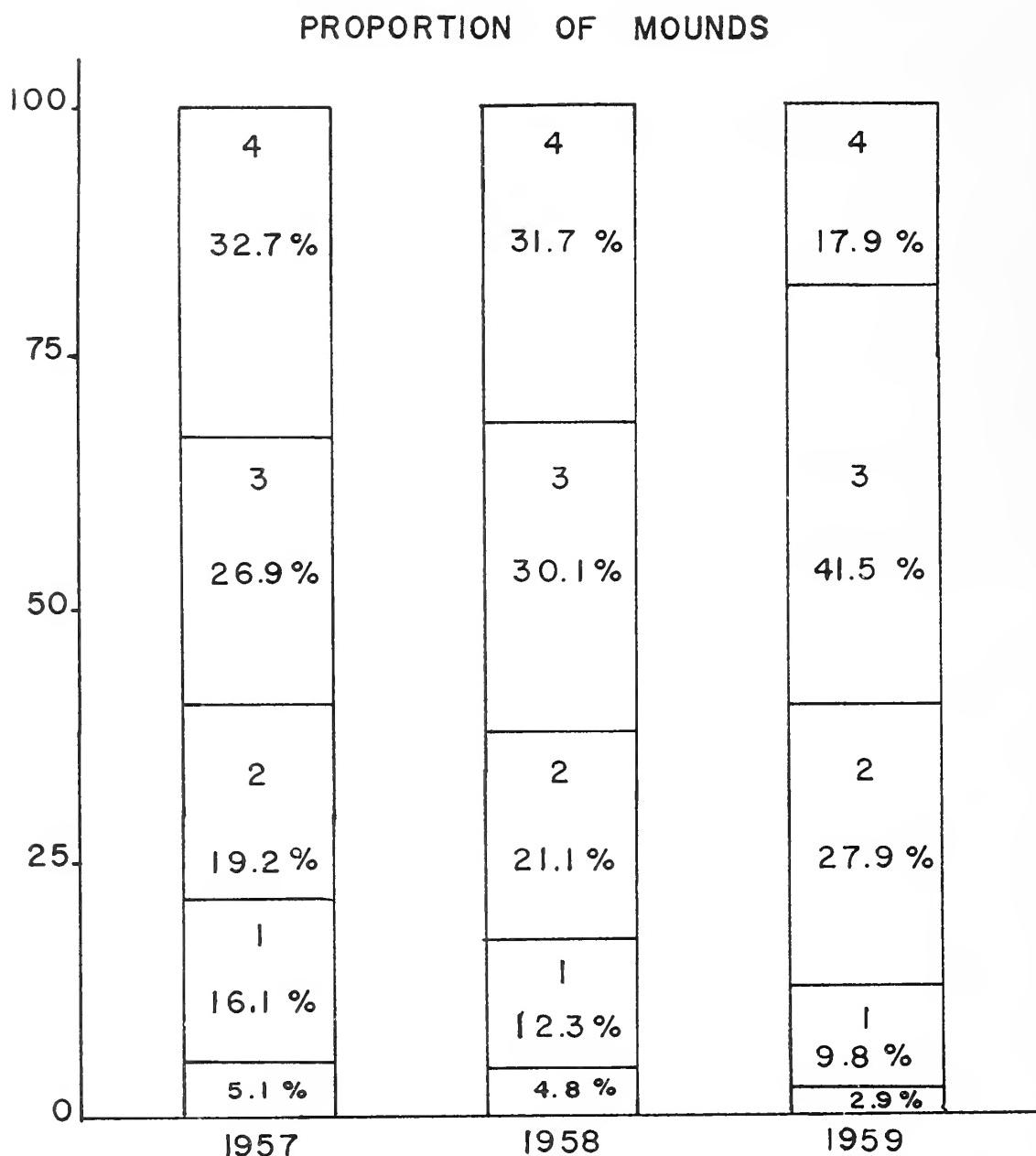


Figure 3 Proportion of mounds in percent at each activity class, during census in 1957, 1958 and 1959. The lowest group in each column denotes the proportion of level 0 and Unclassified mounds.

sible exception is the increase in number of 1958 level 4 mounds which became level 3 in 1959, and the corresponding decrease in the number of 1958 level 3 mounds which became level 4 in 1959 (Table III). These changes, which involve decreased sur-

face nest building activity, occurred during a period of extremely low rainfall, the dry spell of July, 1959. Mean precipitation for that month is 0.97 inches. During the period of observation the rainfall in July totaled 1.49 inches in 1957, 1.16 inches in 1958, and 0.13 inches in 1959 (data kindly furnished by Mr. James

TABLE III
CHANGES IN ACTIVITY CLASS MEASURED IN 1958 AND 1959

Class Change	1958		1959	
	n	%	n	%*
4 to 3	33		55	
4 to 2	5		1	
4 to dead nest	0		1	
Total	38	27.14	57	45.23
3 to 4	22		4	
3 to 2	24		25	
3 to 1	6		2	
3 to dead nest	5		1	
Total	57	49.56	32	26.66
2 to 4	1		1	
2 to 3	16		19	
2 to 1	18		9	
2 to 0	3		0	
2 to dead nest	9		5	
Total	47	57.31	34	40.47
1 to 3	2		3	
1 to 2	8		10	
1 to 0	11		5	
1 to dead nest	28		18	
Total	49	71.01	36	73.46
0 to 2	1		3	
0 to 1	2		2	
0 to dead nest	6		8	
Total	9	81.81	13	86.66
Unclassified to 3	4		1	
Unclassified to 2	2		1	
Unclassified to 1	1		2	
	7		4	
TOTAL CHANGES	207	48.36	176	44.22

* Percentages are based on the total number of mounds at that level during the previous census.

Braman, U.S. Bureau of Reclamation, Moran, Wyo.). Experimental results indicate that we might expect just this kind of decrease in nest building during periods of low rainfall (Scherba, 1961), and is therefore a possible explanation of the marked change in activity level proportions observed in 1959.

Mound fertility An earlier report noted that 20%–25% of a large sample of the population of mounds released winged sexuals during the days of mating flights in 1957 and 1959. We have called such nests fertile mounds and we now wish to inquire whether relationships exist between mound fertility and size, activity level and location within the population.

We have compared the proportion of fertile mounds at each size class and activity level with the proportion of mounds at each size class and activity level in the total sample of mounds examined. This comparison indicates that there were significantly fewer fertile small mounds in 1959 ($\chi^2 = 4.31$; $p < .05$) significantly fewer fertile level 1 and level 2 mounds ($\chi^2 = 8.05$; $p < .01$) and, correspondingly, significantly more fertile level 3 and 4 mounds ($\chi^2 = 7.4$; $p < .01$) in 1959, than would be expected if fertility were equally distributed among the size classes and activity levels.

For purposes of mapping the location of mounds, the study area has been subdivided into quadrants, NE, NW, SE and SW, and the proportion of fertile mounds in each area has been compared to the number of mounds sampled in that area. In both 1957 and 1959 the proportion of fertile mounds was significantly greater in the NW quadrant ($\chi^2_{1957} = 13.34$; $p < .001$: $\chi^2_{1959} = 5.11$; $p < .025$). Of the total of 17 mounds which liberated females during the period of census, 10 were located in the NW quadrant.

On the basis of these comparisons we conclude that fertile mounds are more likely to be found among the larger, more active segments of the population of colonies and in the NW quadrant of this study area.

Mortality Of the 428 colonies censused in 1957, 48 died in 1958 and 26 in 1959, a mortality rate of 9.0%. For the 398 mounds of the 1958 population, 32 colonies died in 1959, a mortality rate of 8.04%. However, the frequency of dead nests was not distributed equally throughout the study area, but was highest in the SE quadrant. Both in 1958 and in 1959 the mortality rate decreased at each activity level from 0 through 4 (Table IV). Further, the mortality rate was very high among newly established mounds. Of 20 colonies founded in 1958, 7 were dead in 1959, a mortality rate of 35%.

A total of 81 colonies died during the period of observation

from 1957 through 1959. Factors which contributed to this mortality are obscure; however, in 13 cases the colonies were replaced by other species of mound-building ants.

Natality New mounds are formed by budding from established nests during the summer months of ant activity. At present, there is no evidence that fertile queens found colonies independently, or by temporary social parasitism of *F. fusca*.

TABLE IV
RELATIONSHIP BETWEEN ACTIVITY CLASS AND MORTALITY

Activity Level	1958		1959	
	Number of Dead Nests	% of 1957 Nests	Number of Dead Nests	% of 1958 Nests
0	6	54.55	8	53.33
1	28	40.58	18	36.73
2	9	10.97	5	5.95
3	5	4.35	1	0.83
4	0	0.00	1	0.79

TABLE V
COMPARISON OF POPULATION CHARACTERISTICS OF MOUNDS

Activity Level	1958			1959		
	NW	SE	In the Total Population	NW	SE	In the Total Population
Birth rate ¹	4.96%	1.15%	4.67%	15.52%	8.45%	12.81%
Death rate ¹	6.61	20.69	11.21	8.62	12.68	8.29
4 Mounds	42.24	12.68	31.66	24.41	8.82	17.90
Large Mounds	7.44 ²	18.39 ²	10.28 ²	8.66	19.12	10.50

¹. Expressed as a percent of the mound population of the preceding year.

². 1957 data.

In 1958, 20 new colonies were founded, nest birth rate, 4.7% and in 1959, 51 colonies were founded, nest birth rate 12.8%. Expressed as the number of established nests per new nest, there was 21.4:1 in 1958 and 7.8:1 in 1959. Nest birth rate was not uniform in all areas; the SE quadrant had the lowest rate, 1.15% in 1958 and the NW the highest, 15.5% in 1959.

New colonies are founded in abandoned mounds of *F. opaciventris*, in mound nests occupied by *F. fusca*, in ant-mined soil at

the base of sagebrush, in soil clumps mined by pocket gopher digging, and, rarely, in soil that was not already worked.

DISCUSSION

Comparison of the population characteristics now available for the North American *exsecta* species shows substantial agreement in order of magnitude of maximum density, nest birth rate, and death rate among these species (Table VI). These characteristics would appear to result from certain specialized features found in this group of ants; return of fecundated females to established nests, polygyny, high worker density and the formation of new nests by budding.

Although data are not available from other ant species, it is

TABLE VI
COMPARISON OF POPULATION CHARACTERISTICS AMONG
EXSECTA SPECIES

Species	Maximum Density (colonies/ sq. meter)	Nest Birth* Rate in %	Death Rate* in %	Source
<i>F. exsectoides</i>	0.015	4.5% - 9%	Andrews (1926)
<i>F. ulkei</i>	0.020	9% - 16%	6% - 9%	Dreyer (1942) Scherba (1958)
<i>F. opaciventris</i>	0.041	5% - 13%	8% - 9%	Present study

* See text for explanation of these terms, as used here.

instructive to contrast the *exsecta* situation with the observations of Wildermuth and Davis (1931) who estimated that in an 80 acre alfalfa field in Arizona, 80,000 to 100,000 *Pogonomyrmex* queens were released per acre, in the Fall. The following year there were no new nests, although unsuccessful incipient colonies were abundant.

One of the surprising characteristics of the population under discussion is the release of sexuals from the mound. This involves only about one quarter of the population of mounds each year, probably on a rotating basis. Thus none of the mounds which released females in 1957 did so in 1959, and half of the sample mounds fertile in 1957 were sterile in 1959.

A mechanism which could account for this situation is suggested by the work of Brian (1953, 1954) who has demonstrated

that production of sexuals is related to the worker/larva ratio in the colony. Lange (1956) has, also, related the production of fertile offspring to the size of the worker population in *F. rufa*. Differential sex ratios, such as those reported here, have been explained on the basis of temperature differences between mounds of different size, smaller mounds tending to have lower temperatures and more males (Lindauer, 1962).

SUMMARY

Population characteristics are described for approximately 400 mound nests of *Formica opaciventris* censused over a 3 year period in Wyoming. During this period of observation, density remained stable at 0.007 nests/sq. meter with a maximum density of 0.04 nests/sq. meter.

Mounds are categorized into size and activity classes and yearly changes are noted. Only a portion of the population releases sexuals, and on a statistical basis these fertile mounds are more likely to be found among the larger, more active segment of the population, and in the NW quadrant of this study area.

Mortality rate for the total population was 8%–9%, increasing regularly at lower activity levels. Nest birth rate was 5%–13% during the period of observation. These rates are compared with those of closely related species of *Formica*.

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TARANTULA LIFE HISTORY RECORDS¹

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ABSTRACT

The growth and development in size and weight are given for four tarantulas. Tarantulas reach maturity in from 8 to 13 years. Mature males usually live for 2-3 months; mature females may live ten or more years. Very young tarantulas may be fed on termites; older ones on grasshoppers and June beetles.

Rearing tarantulas and keeping them until they die of old age constitutes a long time project. Since tarantulas are cannibalistic they must be isolated and given individual attention. This care and attention may continue for twenty years or longer. Time and the attention they require prevent rearing of large numbers together. In this paper I present a relatively complete record of the growth of both males and females.

Young tarantulas, from the time they emerge from the cocoon late in August or early September, apparently do not feed until the following May. After that, if a large family is left together in a jar for several months the young serve each other as food. Water is required every three or four days.

When a limited number have been isolated, they are fed termites two or three times a week. Later the spiderlings are able to manage small grasshoppers. Subsequently they are fed, once or twice a week, on June beetles from April until August and on grasshoppers through September and October. They are given water once a week. In winter they are transferred from the laboratory to my basement and water is supplied every ten days.

Measurements and weighings were made in the fall, after the last feeding, and again in spring before the first feeding. Length of the body includes the upper segment of the chelicerae; length of the carapace is from the middle front to the notch in the rear. These measurements were made with a sharp-pointed caliper. Weights were determined on a torsion balance on or near the

¹ Approved for publication by the Director, Experiment Station University of Arkansas.

same day the measurements were taken. The very small tarantulas were placed in a small, suitable container; the larger ones in a cardboard box about 4 inches square.

Body length measurements, as described here, may not accurately determine size but, when repeated bi-annually over a period of 20 years, may be regarded as a fairly good record of the increase in length of the carapace. Even so, it does not readily tell the size of the animal, nor its rate of growth.²

RATE OF GROWTH

A2, (Table 1.) a male, was reared from young that emerged

Table 1. A2.

Date	Length of Body (mm)	Length of Carapace (mm)	Weight in grams
Feb. 9, 1927	5.5		
Jan. 7, 1928	8.1	2.5	
Mar. 5, 1929	14.5	4.8	.2407
Oct. 7, 1929	20.5	6.2	.8339
Apr. 1, 1930	20.5	6.8	.8045
Oct. 17, 1930			2.6190
Apr. 1, 1931			2.4443
Oct. 20, 1931	38.0	11.3	6.3955
Apr. 13, 1932	37.8	11.8	5.4810
Oct. 11, 1932	40.5	14.7	7.1107
Apr. 6, 1933	42.6	14.7	7.3520
Oct. 7, 1933	46.5	15.7	10.1100
Apr. 18, 1934	45.5	16.0	9.7215
Oct. 30, 1934	47.1	17.1	10.9365
Apr. 12, 1935	47.5	17.2	10.6616
Nov. 6, 1935	49.5	17.3	11.9282
Apr. 18, 1936	48.0	16.8	11.4255
Sept. 5, 1936	47.7	18.1	11.8336
Oct. 7, 1936	48.4	17.6	10.8491

from the cocoon in August 1926. He matured August 23, 1936, at an age of ten years and died August 31, 1937. During his adult life this male constructed 17 sperm webs between September 3 and October 16. He mated 12 times with 4 different females.

A4, (Table 2.) a female, was reared from the same lot which started with eight individuals, but was reduced to four; A1, A2, A3, A4. Her life history began in August 1926. She matured August 25, 1936, at age 10; she died July 17, 1938. After reaching maturity, she mated 5 times with 3 different males from Sept.

² Unless otherwise indicated, the measurements and weights refer to the species common in Arkansas, *Aphonopelma hentzi* Girard.

Table 2. A4.

Date	Length of Body (mm)	Length of Carapace (mm)	Weight in grams
Feb. 7, 1927	5.5		
Jan. 7, 1928	9.8	3.7	
Mar. 5, 1929	16.4	5.6	0.3386
Oct. 7, 1929	20.3	7.1	0.8200
Apr. 1, 1930	21.1	6.9	0.8668
Oct. 17, 1930			2.8316
Apr. 1, 1931			2.6175
Oct. 20, 1931	39.7	14.0	6.0550
Apr. 13, 1932	38.5	14.0	5.7878
Oct. 11, 1932	43.4	15.5	7.3144
Apr. 14, 1933	42.7	15.5	7.8457
Oct. 9, 1933	50.0	16.8	11.2522
Apr. 18, 1934	47.6	16.8	10.6800
Oct. 30, 1934	48.4	18.5	11.3900
Apr. 12, 1935	48.9	17.7	10.9556
Nov. 6, 1935	48.0	17.7	10.3416
Apr. 18, 1936	47.5	18.0	10.5289
Sept. 5, 1936	49.0	18.6	11.7001
Oct. 7, 1936	50.0	19.1	11.7401
Oct. 22, 1937	47.2	18.4	10.2845
Apr. 1, 1938	48.5	19.1	11.6342

Table 3. E4.

Date	Length of Body (mm)	Length of Carapace (mm)	Weight in grams
Oct. 11, 1932	4.1-4.5	1.7-1.5	.00566
Apr. 14, 1933	5.3-6.2	1.4-1.6	.0125
Oct. 9, 1933	8.5	2.3	.0579
Apr. 18, 1934	9.0	2.7	.1135
Oct. 30, 1934	12.3	3.6	.1620
Apr. 12, 1935	12.0	4.3	.1284
Nov. 6, 1935	15.3	5.4	.3248
Apr. 18, 1936	15.5	5.0	.3070
Oct. 7, 1936	16.8	6.0	.4278
Oct. 22, 1937	16.7	6.2	.4170
Apr. 1, 1938	17.5	6.6	.3713
Oct. 26, 1938	19.0	6.5	.6268
Apr. 18, 1939	19.5	7.0	.6666
Nov. 3, 1939	24.7	9.2	1.3585
Apr. 6, 1940	24.2	9.1	1.2140
Nov. 7, 1940	30.0	10.0	2.5400
Apr. 16, 1941	32.0	10.8	2.8875
Oct. 28, 1941	31.0	11.4	2.6320
Apr. 16, 1942	33.3	11.16	3.2400
Oct. 27, 1942	34.6	12.2	3.7120
Apr. 17, 1943	31.5	12.3	4.7500
Nov. 1, 1943	38.1	13.8	5.0110
Apr. 22, 1944	47.8	13.7	4.9550
Nov. 8, 1944	44.3	15.8	7.5500
Apr. 18, 1945	48.5	16.4	7.1750

3 to Sept. 27, 1936. She made a cocoon on July 2, 1937 which contained 736 eggs.³ These failed to hatch. In her annual molt in July 1938 she had difficulty and died soon after. She had not fed since the preceding fall.

E4, (Table 3.) a male, represents another lot that emerged from the cocoon August 13, 1932. He matured August 27, 1945, at the age of 13 years and 2 weeks. He died November 7, 1945.

Table 4. Señora Belmar.

Date	Length of Body (mm)	Length of Carapace (mm)	Weight in grams
Oct. 30, 1934	49.2	15.7	10.7375
Apr. 12, 1935	47.8	15.6	10.2800
Nov. 6, 1935	52.3	18.3	12.1581
Apr. 18, 1936	52.2	18.2	12.9747
Oct. 7, 1936	53.3	19.8	12.9425
Oct. 22, 1937	54.7	19.1	14.8345
Apr. 1, 1938	56.6	19.6	16.2042
Oct. 26, 1938	53.3	19.4	14.3797
Apr. 19, 1939	57.2	20.0	16.5013
Nov. 3, 1939	58.0	20.4	17.6650
Apr. 6, 1940	58.2	20.7	18.3800
Nov. 6, 1940	60.0	21.3	16.9020
Apr. 16, 1941	59.0	21.6	18.7350
Oct. 28, 1941	58.9	21.0	17.209
Apr. 16, 1942	64.3	21.5	22.225
Oct. 27, 1942	62.2	22.2	21.605
Apr. 17, 1943	64.2	21.4	24.382
Nov. 1, 1943	61.7	22.6	20.892
Apr. 22, 1944	66.5	22.7	24.175
Nov. 8, 1944	63.1	24.1	26.033
Apr. 18, 1945	67.6	24.0	28.965
Nov. 14, 1945	67.4	23.2	26.630
Apr. 19, 1946	69.8	24.5	29.950
Nov. 13, 1946	64.1	24.6	23.487
Apr. 30, 1947	69.6	25.4	26.387
Nov. 20, 1947	68.0	24.3	25.607
Apr. 14, 1948	69.2	24.0	28.785
Nov. 13, 1948	65.5	24.2	23.602
Apr. 21, 1949	66.2	26.1	22.636
Nov. 28, 1949	63.2	21.14	19.915

He made only one sperm web but failed to mate with either of two females.

My best example of female longevity is a tarantula taken in September 1934, near Nazathan, Sinaloa, Mexico. This species is pale grayish-brown in color and slightly larger than the common Arkansas species. For lack of the proper technical name, I have called her "Señora Belmar." (Table 4.) Judging from

³ In other cocoons examined the number of eggs has ranged from 631 to 1018.

her size she was mature when captured. In contrast to most tarantulas that are easily handled, she fiercely resisted efforts to hold her while being measured; once she managed to bite me. This attitude, she steadfastly maintained until she died nearly 16 years later.

LONGEVITY

The tarantulas observed crossing highways in early fall, are mature males. Their lives are brief, even if not killed by motorists, and when brought into the laboratory they live for only a few weeks, rarely until the end of December. Out-of-doors some males survive the winter every year, as is shown by the appearance of mature males on the highways and elsewhere during late May and the first half of June.

In the laboratory mature males reared from newly-emerged or partly grown individuals may live through the winter and well into the next year. I have records of mature males living 7, 10, 11, 17, and 20 months. Usually males reach maturity in 9 or 10 years. I have one record for 8 and one for 13 years. Mature status is easily recognized by the enlarged distal segment of the palpus which carries the intromittent organ. There is also a distinct change in color. Newly transformed males are a very dark brown and have a bright golden carapace.

Female tarantulas are stay-at-homes. Occasionally a young, or a mature female tarantula is found wandering about, apparently in search of a better place to stay. To collect females one has to find them where they live, under stones or in holes. Maturity is not so easily and definitely recognized in this sex. I have depended mainly on size and on willingness to mate. A4 and A2 were siblings. The easily recognized mature male, A2, mated with the female, A4, of the same age. In this pair maturity was reached in 10 years. This is probably the usual time required. After reaching maturity the females may live for a number of years. A4 disappointed me when she died a little more than 2 years after maturing.

A female of the Arkansas species, Mc16, taken as a 2-year old, matured at age eleven and died at the age of 22 years and 4 months. Another local female, WH1, taken as a 7-year old, Sept. 17, 1925, lived till August 8, 1938, reaching an age of about 20 years. A large female *Dugesiella crinita* from Tlahualilo, Mexico, lived for 8 years and 10 months; a brown-banded species

from Santiago, Mexico, lived for 9 years; and the golden-banded species from Guerrero, *Aphonopelma smithi*, lived for nine years. All of these may be considered as having attained an age of about 20 years.

MOLTING

The young tarantulas go through their first molt before they leave the cocoon, or immediately thereafter. The following year they molt 3 or 4 times; the tiny skins are easily overlooked. In the following year there are again 4 molts, and during the following three years there are 2 molts. After that there is one molt a year. A large female *Dugesiella crinita* from Tlahualilo, Mexico, old age. Rarely, mature females molt twice during the season, April to November, and, occasionally, a mature female misses a molt. This seems to be more common in the Mexican species than in native ones. "Señora Belmar" missed three molts during the fifteen years of her adult life. Another species, *Aphonopelma emilia*, apparently molts regularly once every other year.

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NEW SARCOPHAGINE FLIES (DIPTERA: SARCOPHAGIDAE)

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ABSTRACT

Sarcophaga downsiana, new species, Venezuela; *Sarcophaga filamenta*, new species, Dutch Guiana (Surinam); *Endemimyia vaurieae*, new species, Mexico are new neotropical species described and figured from the male sex. *Sarcophaga (Idoneamima) footei*, new species, is described from male,

female and puparium, reared from snails, New York. The posterior spiracular concavity is extremely shallow in *footei* puparia.

Three of the new flies reported here are represented by uniques in the American Museum of Natural History, where these descriptions were prepared. The author expresses his appreciation to the museum authorities for the facilities and courtesy provided. Two are referred to *Sarcophaga* in its broadest sense, simply because they do not seem to pertain to any of the numerous restricted genera which have been proposed. The fourth species was reared from snails in New York.

Sarcophaga downsiiana, new species

Figures 1 to 3

LENGTH 8 mm.; wing 7 mm. A black fly with bright golden pollinosity; 3 posterior dorsocentrals; wings clear, vein 1 bare; legs black, mid tibia with a comb, hind tibia non-villous; genital segments black.

MALE. Head with front at narrowest (before ocelli) 0.163 of head width; inner vertical large, outer vertical absent, ocellars weak, proclinate; frontal stripe black, parallel-sided, half the width of front at narrowest; parafrontofacials bright golden, with a row of minute black setules; frontal rows of 10-11 pairs, moderately divergent to middle of second antennal segment; antenna black, arista plumose; vibrissa at epistoma; facial ridge setuled 0.33 to lunule; cheeks 0.17 of head height, black haired; palpi black; occiput black-haired.

Thorax yellow pollinose, with 3 black stripes; chaetotaxy: acrostichals 3:1, fine; dorsocentrals 3:3, large; intraalars 2:3; supraalars 3; humerals 3; notopleurals 4; posterior callus 2; scutellars 2 strong marginal, 1 fine apical, 1 fine preapical; sternopleurals 3, the middle lower than the others; propleuron, prosternum and mesosternum haired; hind coxae haired posteriorly. Wing clear, veins dark, vein 3 setuled 0.66 to cross vein, epaulet black; squama whitish, the lower lobe brownish discally. Legs black, mid femur with a comb of 6 spines; hind tibia non-villous.

Abdomen yellow pollinose, especially on sides, with 3 longitudinal black lines; third apparent tergite without median marginals; sternites 1-4 gradually decreasing in width, with fine, small, black hairs; sternite 5 elongate, pollinose, nearly devoid of hairs, with a very small, V-shaped notch. Genital segments black, yellow pollinose, the first with a marginal row of 8 bristles. Penis and forceps as figured, the penis two-segmented, with a large, anteriorly-directed ventralia from the base of the distal segment; claspers concealed in lateral view, about equal size and moderately curved.

Female unknown.

HOLOTYPE male, Cerro Avila, Caracas, Venezuela, April 14, 1957, 2000 meters alt., W. G. Downs collector, in American Museum of Natural History, through the courtesy of Dr. Downs.

Sarcophaga filamenta, new species

Figure 4

LENGTH 6 mm., wing 5 mm. A small, greyish fly with vein 1 setuled, hind tibia non-villous and genital segments reddish. The genitalia are unlike any other species known to the writer, the most prominent feature being a long, curved filament arising from the anterior face of the penis; this suggesting its specific name.

MALE Front at narrowest 0.216 of head width; frontal rows of 7 pairs, hardly diverging anteriorly; frontal vitta black, parallel-sided, 0.4 width of front at narrowest; parafaciofrontals silvery grey, with 2 rows black setules; proclinate frontoorbitals absent; cheek 0.19 of head height, cheek and occiput white-haired; 2 rows of black postocular hairs; inner vertical large, ocellars small, proclinate.

Thorax grey with 3 black stripes; chaetotaxy: acrostichals 0:0; dorsocentrals 1:4; intraalar 0:1; supraalar 2; humerals 3; notopleurals 4; sternopleurals 3, the middle one slightly below the others and closer to the anterior; scutellars 2 marginal, 0 apical, 1 small subapical; prosternum, metasternum and hind coxae posteriorly setuled; propleuron bare. Wing hyaline, veins brownish, vein 1 setuled on basal half, vein 2 setuled to cross vein; epaulets black; squamae white, the lower lobe with a slight brownish cloud. Legs black, mid femur without a comb; tibiae non-villous.

Abdomen black, with the usual grey pollinose checkered pattern; third apparent tergite with strong median marginals; sternites 1-4 of about uniform width, clad with rather long black hairs on the sides, with a bare median stripe on sternites 2-4, the stripe becoming broader and shining on sternite 4; sternite 4 apically with a patch of dense bristles; sternite 5 broadly U-shaped, largely concealed, with a few small hairs on the arms. Genital segments equal sized, pollinose, first blackish, with a marginal row of bristles, the second red. Genital segments as illustrated (figure 4), the forceps much as in *Helicobia*, contiguous, finely haired; accessory plate triangular; distal segment of penis bears a long, curved filament; anterior clasper long and stout, with apex bent at right angle, in ventral view it is bent outwards somewhat at the angle.

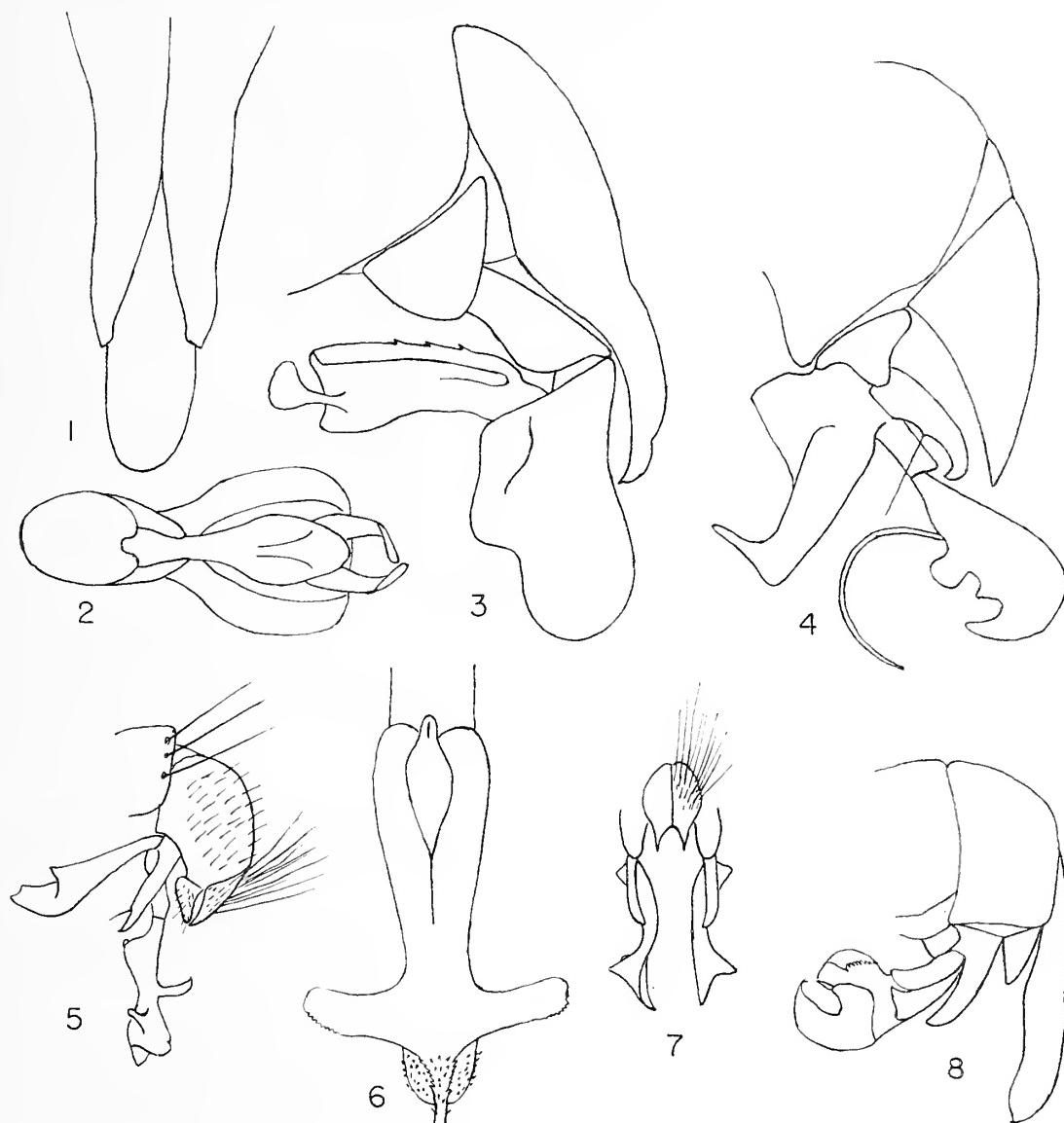
HOLOTYPE male, Dutch Guiana: "Paramaribo, cultuurtuin op laai pari, 14.IV.1940, Geiskses," in American Museum of Natural History. The label is handwritten and I am not certain of the spelling; the collector is Mr. D. C. Geiskses.

Endemimyia vaurieae, new species

Figures 5 to 7

LENGTH 11 mm., wing 9 mm. A medium sized fly with the appearance of *Oxysarcodexia* (sides of thorax and apex of abdomen yellowish pollinose), but frontal rows widely divergent below, faecal ridge bristles 0.66 to lunule and 2 posterior dorsocentrals in a row spaced for 3, the middle bristle missing.

MALE Head 0.66 as long at antennal axis as high; front at narrowest 0.172 of head width; inner vertical large, outer vertical undifferentiated; ocellar rather large; frontal stripe black, gradually widening anteriorly, at narrowest half the width of front; frontal rows of 13 pairs, widely divergent in the lower 3 pair, attaining apex of second antennal segment; lunule recessed; antenna black, third segment 5:1, arista densely plumose



EXPLANATION OF THE FIGURES

FIGURES 1-3, *Sarcophaga downsiiana*, new species. Figure 1, posterior view of apices of forceps and penis; Figure 2, lateral view of genital complex; Figure 3 apical view of penis.

FIGURE 4, *Sarcophaga filamenta*, new species. Lateral view of genital complex.

FIGURES 5-7, *Emdenomyia vaurieae*, new species. Figure 5, lateral view of genital complex; Figure 6, anterior view of distal segment of penis; Figure 7, ventral view of forceps and claspers.

FIGURE 8, *Sarcophaga (Idoneamima) footei*, new species. Lateral view of genital complex.

on basal 0.75, the dorsal rays in a double row for a distance from the base. Parafrontofacials yellow pollinose, with a row of minute black setules, abbreviated below; postocular orbits yellow; clypeus moderately depressed, vibrissa at epistoma; facial ridge setuled 0.66 to lunule; cheeks yellowish, 0.21 of head height; cheeks and occiput black-haired, a few white hairs about the neck; palpi black, equal to third antennal segment.

Thorax black, greyish above with 3 black stripes, becoming yellowish pollinose on the sides. Chaetotaxy: acrostichals 3:2, anterior fairly strong, posterior very strong; dorsocentrals 3:2, posterior 2 in a row spaced for 3, the middle absent, or possibly displaced to the acrostichal row; intraalars 2; supraalars 3, humerals 3, notopleurals 4, posterior callus 2; scutellars 3 marginal, 1 preapical and an apical hair-like pair which are not crossed but upturned; propleuron densely haired; prosternum haired; sternopleurals 3, the middle one slightly below the others and nearer the anterior; metasternum setuled; hind coxa setuled posteriorly. Wing hyaline, with dark brown veins; vein 3 setuled 0.5 to cross vein; vein 1 bare; epaulet black; squamae whitish, lower lobe with dark hairs, distinct from microtrichia, on its outer margin. Legs black, mid femur without comb; hind tibia sparsely villous, mid tibia non-villous.

Abdomen black with the usual checkered pattern, grey pollinose above on first 3 segments, the 4th yellow pollinose above, yellow pollinosity on sides of third and fourth segments. Sternites 1-4 with fine, sparse, black hairs, the posterior margin of 4 with a few longer ones; sternite 5 reddish, shining, narrowly cleft to base, very sparsely clad with fine setules, its apex broadly V-shaped, slightly protuberant in profile. Genital segments reddish brown, setuled, yellow pollinose, the first with an interrupted marginal row of 4 pairs weak bristles; genital segments as illustrated (Fig. 5-7); forceps small, not exceeding the accessory plate, parallel, the tips separated on apical 0.2, base strongly haired; penis 2-segmented, the distal segment with a blade-shaped hooked process on its back and 2 black lateral arms subapically; anterior clasper immense, black, broadened and forked on apical half.

HOLOTYPE male "Tamazunchale, Mex., 350 feet alt., 9.IX.1947, C. & P. Vaurie, F. Johnson Donor," in American Museum of Natural History.

This species resembles *E. myersi* (Curran) and *spinosa* Lopes in its elongated antenna 3, long bristled facial ridges, setulose propleura and unusual chaetotaxy of the postnotum (acrostichals and dorsocentrals). It differs by the "trilobed" distal segment of the penis, the immense anterior clasper, and the better differentiated anterior acrostichals.

Sarcophaga (Idoneamima) footei, new species
Figure 8

LENGTH 10 mm., wing 9 mm.

MALE Front 0.171 of head width; frontal rows of 13 pairs, widely di-

verging toward lunule. Thoracic chaetotaxy: acrostichals 0:1; dorso-centrals 3:3; intraalar 1:2; supraalar 2:3; humerals 3; notopleurals 4; posterior callus 2; scutellars 3 marginal, 1 preapical, and moderate sized, cruciate apical pair. Wing hyaline, veins dark brown, third vein setuled at base. Legs black, bristly, mid femur without comb, hind tibia non-villous.

Abdomen black with the usual checkered pollinose pattern; genital segments red, the first pollinose, with a marginal row of bristles, segment 2 shining, yellow-red. Forceps black, slightly bent, united for 0.66 their length at base, claspers subequal, anterior pair slightly larger; penis with claw terminating in a pair of very fine filaments; anterior lobe with a thin, translucent median keel, on either side of which a finely frayed margin.

FEMALE Front 0.286 of head width, with 2 proclinate frontoorbitals; otherwise similar to the male, with the usual sexual differences.

Puparium 9 mm. long; posterior spiracles in a very shallow, flat or "convex concavity" bordered by a circular, slightly raised and nearly smooth rim; anterior spiracles projecting, ear-shaped, with numerous pores.

HOLOTYPE male and allotype female, Mt. Pleasant, Tompkins Co., N.Y., April 22, 1957, B. A. Foote, with pinned puparia, "1-V-57, F-5709C," reared from snails, in Cornell University collection.¹

PAPATYPE, one female, same data as above, in United States National Museum.

This species keys in Dodge (1956, page 244) to couplet 22 of the first key, where it is distinguished by the hind tibia non-villous. In the alternate keys it runs to *parallela* and *sudai* in couplet 3 and resembles *parallela* in having forceps slightly bent but differs from it by having no constriction in the forceps at the bend, as seen in posterior view.

Literature Cited

- Dodge, H. R., 1956. A new sarcophagid genus with descriptions of fifteen new species. Ann. Ent. Soc. Amer., 49 (3): 242-263.

¹ Dr. Foote informs me in correspondence that Rearing No. F-5709C is "one male, two females from a cleaned out shell of *Triodopsis notata* Deshayes collected. 22 April, 1957. Relationship to snail unknown. Puparia were found in the shell."

A NEW SPECIES OF APHAENOGASTER
(*ATTOMYRMA*) FROM THE WESTERN UNITED
STATES (HYMENOPTERA: FORMICIDAE)

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ABSTRACT

This widely distributed and common ant of crepuscular habit, *Aphaenogaster (Attomyrma) megommatus*, n. sp., is described from workers collected one mile north of Camp Foster, Pyramid Lake, Washoe County, Nevada. It has also been collected in Nye and Pershing counties of the same state and also in Malheur county, Oregon; Yuma county, Arizona and Inyo county, California. The species is characterized by its extraordinarily large eyes, "callow like" color and obsolescent epinotal spines. The ant bears a superficial resemblance to *Aph. (A.) boulderensis* M. R. Sm. and could well be mistaken for that western species.

This article describes and figures the worker of a new but common species of *Aphaenogaster (Attomyrma)* of our western States. The paper also presents notes on the distribution and biology of this ant. The name *megommatus* refers to the extraordinarily large eyes, one of the outstanding characters of the species. In Creighton (1950, Ants of North America, p. 141), this ant keys out to *boulderensis* M. R. Sm. (1941, Great Basin Nat. 2 (3) : 120), from which it differs in the unusually large eyes, the body color, the more sculptured and stouter body, and other characters.

Aphaenogaster (Attomyrma) megommatus, n. sp.

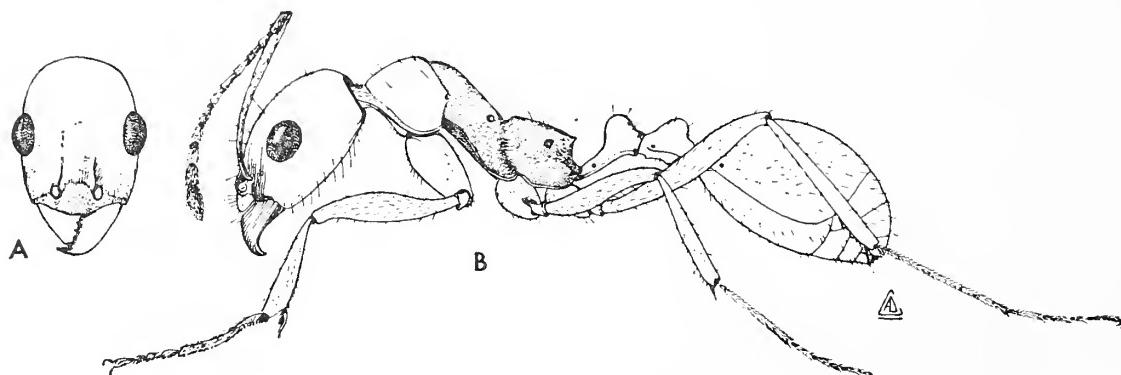


Fig. 1—Worker of *Aphaenogaster (Attomyrma) megommatus*, n. sp.
A, Frontal view of head; B, body in profile. Illustrated by Arthur D. Cushman.

Worker. Length 5.2 mm. Head strikingly slender, excluding mandibles, 1.2 times longer than broad, with weakly convex almost subparallel sides, the posterior portion rounded and narrowed behind the eyes. Eye extraordinarily large and protuberant, 0.35 mm. in its greatest diameter and with 18–20 ommatidia in this linear space. Scape unusually long and slender, gradually broadening toward its apex, the apex exceeding the posterior border of the head by approximately the combined lengths of the first two funicular segments; funiculus slender, with all segments longer than broad, the last 4 or 5 segments perceptibly enlarged but not forming a very distinct club. Middle of the anterior border of the clypeus with a weak but distinct emargination or impression. Thorax in profile with the dorsal surface of the mesothorax sloping obliquely toward the epinotum and forming a depressed or weakly concave outline. Mesoepinotal impression well defined. Base of epinotum subhorizontal, with a medioposterior impression bordered laterally by weak carinae, each ending in a very small tuberclelike spine. Legs rather long and slender, the femora and tibiae not especially enlarged. Anterior surface of petiolar node, in profile, meeting dorsal surface of pedicel at a distinct but weakly defined angle; anterior surface of the petiolar node precipitous, posterior surface of the node oblique. Postpetiole in profile not much larger than petiole; its anterior surface more sloping and its posterior surface less oblique. Gaster from above subelliptical, without basal humeri.

Prothorax, petiole, postpetiole and gaster somewhat smooth and shiny. Mandibles, cheeks, clypeus, mesothorax and epinotum subopaque.

Hairs not abundant or unusually long, present on under side of head as well as on dorsal surface of body. Pilosity of legs generally more abundant than that of body, and also more subereet on tibiae and tarsi.

Color of body under a microscope lamp and at a magnification of 20.7 and 43.2 a sordid light brown or sordid yellow, of a "callowlike" appearance; the large black eyes especially noticeable and forming a strong color contrast with the body.

Type locality. One mile north of Camp Foster, Pyramid Lake, Washoe County, Nevada.

Types. Described from a holotype and 42 paratype workers collected by Ira LaRivers, April 20, 1952, from under a rock in a railroad gravel pit. The holotype and paratype workers have been placed in the U. S. National Museum under U.S.N.M. Type No. 66829.

Other localities. **Nevada:** 10 miles south of Lovelock, Pershing County, May 13, 1951, Ira LaRivers, under a rock associated with *Araeoschizus*; Mercury, Nye County, August 4, 1961, A. C. Cole. **Oregon:** Malheur County, June 14, 1962, R. R. Snelling. **Arizona:** Dateland, Yuma County, 150 ft., October 27, 1952, W. S. Creighton. **California:** 3 miles west of Lone Pine, Inyo County, 4,400 ft., May 3, 1952, W. S. Creighton.

Workers vary in length from 4.4 to 5.2 mm. Paratypes differ from the holotype in their longer and more slender heads; in the epinotal spines ranging in size from almost completely absent to small but perceptible and tuberclelike; in the variable pilosity of some individuals, especially notice-

able on the under side of the head and on the front coxae; and in the variable but weak infuscation of the gaster.

This common ant is widespread and will very probably be found in Utah, Idaho and Mexico. It appears to be largely crepuscular or nocturnal. W. S. Creighton *in litt.* said "—as regards the Dateland, Arizona specimens I can give you a fairly reliable picture of the circumstances under which they were taken even though the field notes for the trip are at the island. In 1952 the highway that runs through Dateland was a dividing line between irrigated land to the south and non irrigated desert to the north. The irrigated area supported, as you would expect, an extensive stand of date palms. The non irrigated area consisted of a sandy area of small dunes about 10–15 ft. high. There were a few bushes and considerable bunch grass but the place was not nearly so sandy as Grey's Well, California, although the sand seemed less prone to shift. We arrived at the station just before dusk and while supper was being prepared, I found the *Aphanogaster* colony which had begun to forage in the dusk and kept it up after dark. There is no doubt that the thing is nocturnal and, what is more, it has its marriage flight at night!—The nest was not at all conspicuous since it consisted of a single nest opening with no crater or mound. I suppose that is because the excavated material is soon displaced by the wind."

R. R. Snelling, who collected the species in Malheur County, Oregon, reported *in litt.* as follows, "These were taken at approximately 10:30 P.M. while foraging. The night was quite cool, 50–52 Fahr., and windy. The sky cloudy, with occasional light showers at the time of the collection. The ants were quite active, and very difficult to capture because of their color and rapid movement. If the color, which blended quite well with the soil, is any indication at all, this species may well be a regular night forager. That the ants were active at such relatively low temperatures would seem to support this view."

THE ANATOMY OF THE ADULT QUEEN AND
WORKERS OF THE ARMY ANTS *ECITON*
BURCHELLI WESTWOOD AND *ECITON*
HAMATUM FABRICUS

ROY M. WHELDEN

[CONTINUED]

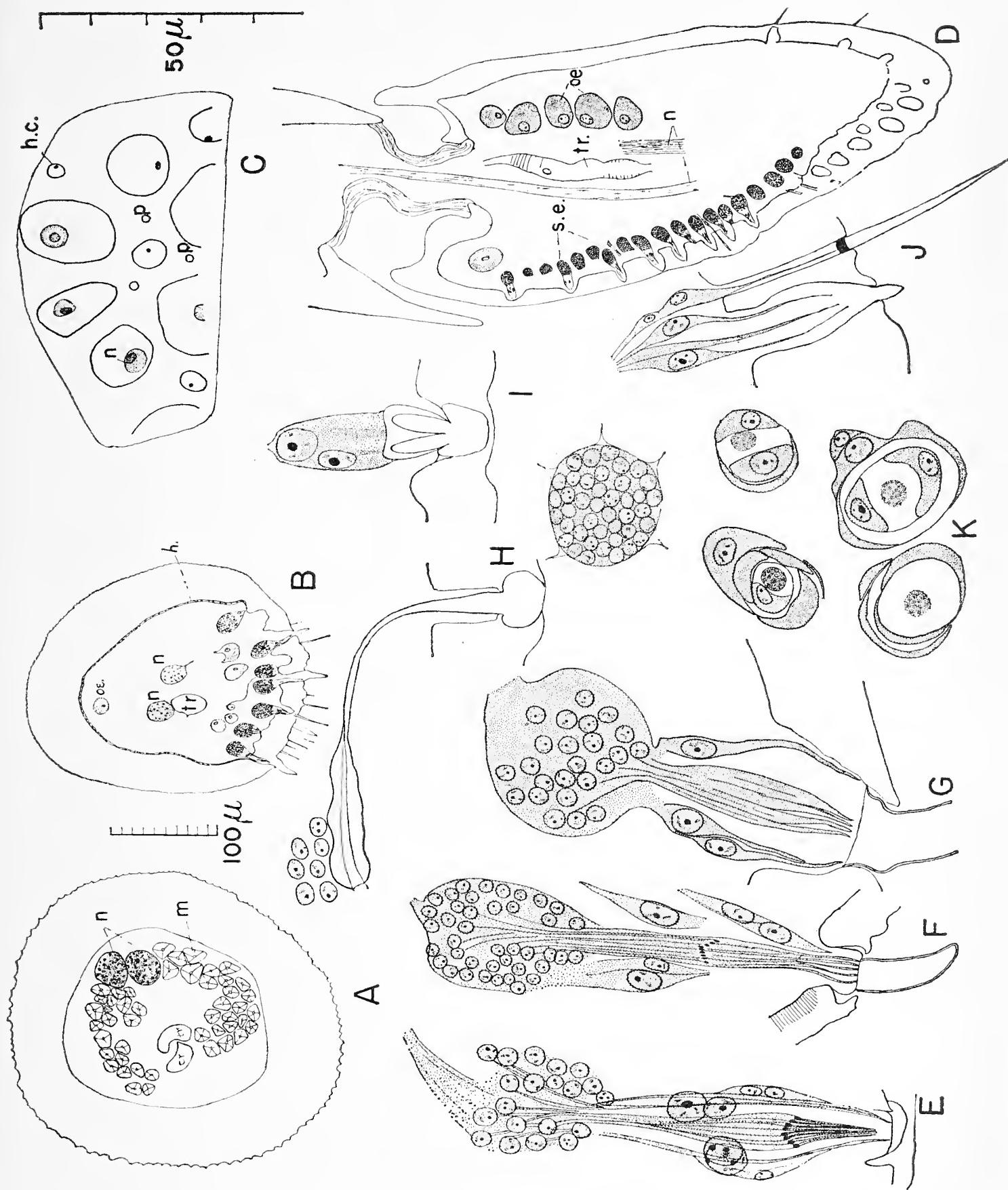
THE ANTENNAE

Early in this paper, the presence of a thickened area in the hypodermis in the antennae was noted (Fig. 16, B). In the head, at the base of each antenna, is a small gland composed of about a dozen cells in the queens and of three or four in the workers. The ducts of these cells open through the mem-

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brane which joins the antennal wall to that of the head. In minor workers this gland may be reduced to a single cell, easily missed if the section is not cut at exactly the right place to show its presence.

The scape offers little of particular interest, its most conspicuous contents being the two relatively large muscles and nerves; in addition to these, are small tracheal branches and an occasional fat cell. The walls of the scape are thick, commonly measuring 50–60 μ and less often reaching 70–80 μ .

The funiculus is more interesting than is the scape. Hairs are relatively few on the scape and usually small, with only a few conspicuously long slender ones, mostly near its apex; whereas all segments of the funiculus are uniformly clothed with hairs. These vary some being slender, acute and 40–50 μ long, others stouter and equally acute, but 70–80 μ long: only near the apex of each of ten lower segments, and uniformly over the entire surface of the eleventh segment, do conspicuously longer and stouter hairs 150–220 μ in length occur. These are tactile hairs similar to those on the body.

In contrast the specialized sensory elements so characteristic

FIG. 13. Antenna.

- A t.s. upper part scape of *E. hamatum* worker, nerves (n.), trachea (tr.) and muscles (m.)
- B t.s. flagellum, showing unilateral sensory elements, two nerves (n.), trachea (tr.), oenocytes (oe.) and thin hypodermis (h.)
- C tg.s. ventral wall, pores (p.), hair canals (h.e.) and nerves (n.)
- D l.s. apical segment of queen flagellum, nerves (n.), trachea (tr.), oenocytes (oe.) and sensory elements (s.e.)
- E Nerve elements in nearly mature medium worker pupa
- F Corresponding elements in callow adult worker
- G Basiciconic sensilla, similar to E and F, from near base of a middle segment of mature major worker flagellum
- H Sensilla ampullaceum or flask-shaped organ of Forel
- I Champagne-cork organ of Forel partially sunk in body of sensory region
- J Antenna callow worker, tactile hair and its nerve (right) and sensory organ with nerves (left)
- K t.s. series through sensory element resembling G. Above, region of small nuclei, two sections in basal half of region of large nuclei. Below, two sections, (right) above middle and (left) near apex of sensory element

of ant antennae are limited to less than one quarter of the circumference of the funiculus (Fig. 13, B). In nearly all the individuals studied, this sensory sector forms a spiral band from the basal to the apical segments. The occasional examples in which this band was nearly straight suggest the possibility that a sweeping movement of the funiculus also causes a slight revolving of each segment over the one below it, the sum of these rotary movements resulting in the spiral appearance. Since no muscle tissue is found in the funiculus, such movement is strictly mechanical, possibly due to the asymmetrical shape of the wall at the base and the apex of each segment. The membrane connecting any two segments is also asymmetrical, being wider and much thicker on one side than on the other.

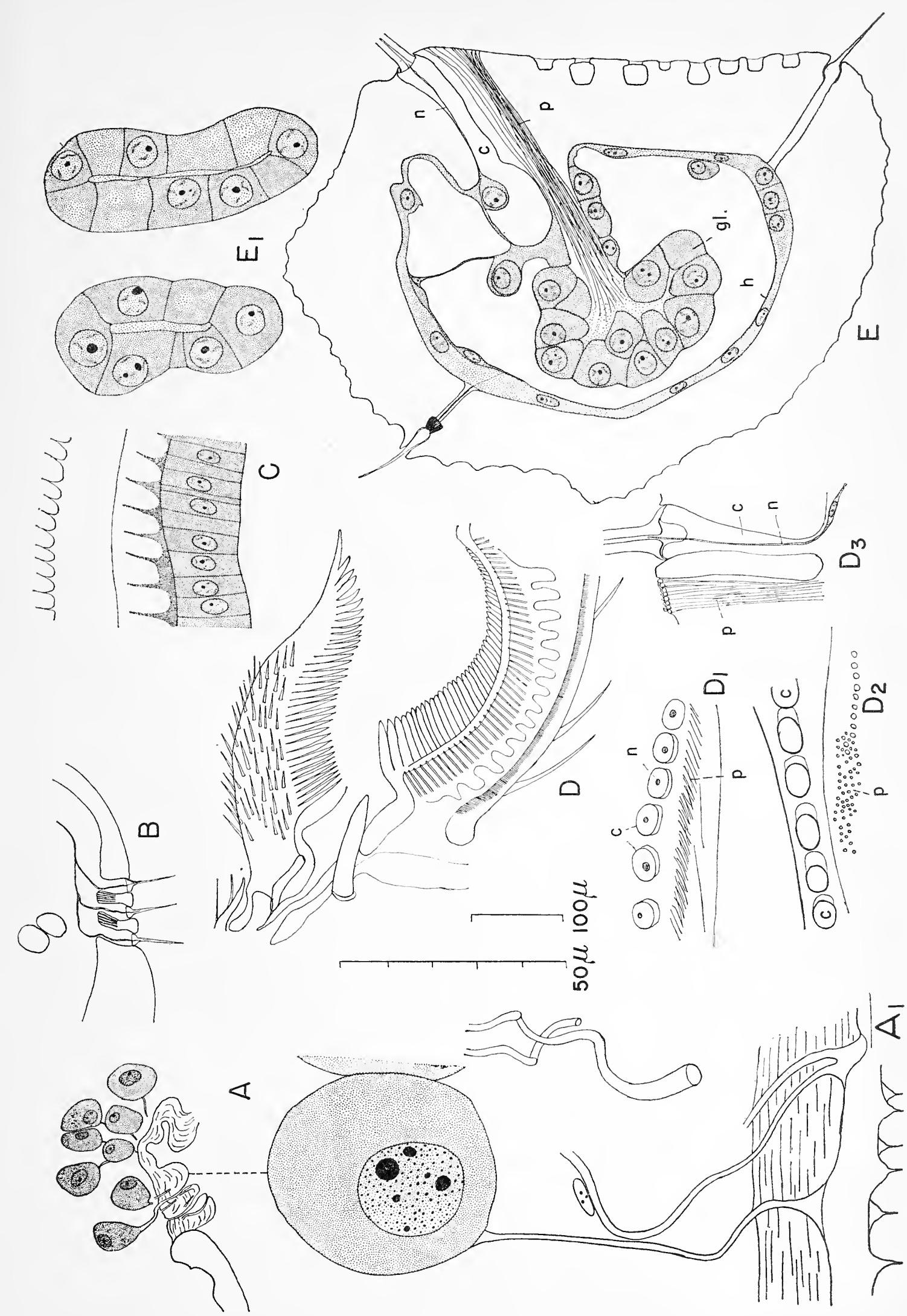
This asymmetry is more obvious internally, especially in callow insects. Callow queens have numerous oenocytes which form a uniform layer under the wall of the segment, a layer broken only by the sensory sector. Even here, oenocytes may be found beneath the cellular element associated with the sensory structures. Within the layer of oenocytes, two large nerves, and tracheal branches are found, extending nearly to the apex of the ultimate segment. Numerous fine nerves pass from the main nerves to peripheral tactile and sensory hairs; small tracheal branches are also present.

The sensory elements are similar to those found in other ants. The basiconic sensilla, having a stout strongly curved spine with bluntly rounded apex is an obvious feature (Fig. 13, E, F, G). They first appear late in pupal development; at which time, the cellular elements characterizing them are well developed, and including the group of small nuclei from the center of which a bundle of nerve fibres extends outwards. Surrounding this is a group of nuclei, several of them many times larger than the small nuclei of the lower group, and several small ellipsoid nuclei, all in coarse cytoplasmic strands extending to the surface of the developing antenna. Within these, the compact group of nerve fibres continues and is made conspicuous by the presence of a cone-shaped group of deeply staining ellipsoid bodies, one in each nerve fibre (Fig. 13, E, F). Above these bodies, the nerve fibres form a rapidly narrowing bundle ending beneath the inner surface of the wall (Fig. 13, E). In older pupae and in newly emerged callows, the structure re-

mains much the same; but the large group of basal nuclei is now surrounded by a limited mass of cytoplasm, the group of deeply staining bodies is less conspicuous, the bodies distinctly smaller, the wall of the antenna is now well-formed and the external spine well-developed but still small (Fig. 13, F). In older ants, all trace of the small darkly stained bodies is gone (Fig. 13, G). Fig. 13, K shows a series of cross-sections through one of these basiconic sensillae, the upper one showing the compact mass of small nuclei, the lower four, different levels through and above the group of large nucleate elements.

Less conspicuous and not numerous are the small peg-like elements shown at the left in Fig. 13, J with its group of slender nerve ends extending into the cavity in the wall: the element at the right in the same Fig. 13, J is one of the small tactile hairs occurring among the sensory elements as well as over the remaining surface of the funicular segments.

Separation of the ampullaceous sensillae (Fig. 13, I) and the flask-shaped organs of Lubbock and Forel (Fig. 13, H) is difficult in these two species of *Eciton*. Between a typical ampullaceous sensilla and a typical flask-shaped organ, the intermediate elements are so finely graded that no real separation into groups is possible. Equally difficult is it to find a flask-shaped organ to describe as typical: the thick basal portion may be very short, its length scarcely exceeding its diameter; or the length may be five times the diameter; the basal end may be broadly rounded, or nearly flat; if flat, it may be at right angles to the long axis, or it may form an angle of 40° with that axis; its lateral walls may be straight, or thrown into regular undulations, or the undulations may be uneven; the central lumen may be of uniform diameter throughout, or it may narrow gradually from base to apex; and may even seem to extend below the base as in Fig. 13, H; the slender tube connecting the apex of the basal portion to the wall of the antenna may be many times the length of the basal portion, or it may be very short; it may be of uniform diameter throughout, or it may flare conspicuously as it passes through the thickness of the wall; and finally, by gradual stages a typical ampullaceous sensilla, is seen all in a single antenna. This is the condition found in certain individuals; in others, there is no indication of transition from one type of element to another.



LEGS

The small glands found in the ventral part of the thorax, at the base of each leg (Fig. 14, A) have already been mentioned. Similar glands are found in the distal end of each segment. The number of cells found in each gland mass varies slightly in any form, much more when various forms are compared. The gland mass found in the coxal segment, with ducts opening through the membrane joining the segment to the trochanter varies from 8–10 cells in queens; 5–7 cells in large and medium workers; and 4–5 cells in minors. In lower segments, the number of cells in any gland seem to be less than in the upper segments. Often, gland cells are absent in tarsal segments of the smaller forms, which may be factual or merely that it is difficult to recognize a gland cell because of an unsuitable—angle of sectioning: recognition is often made more difficult by the large number of oenocytes present in the segments of the legs—but oenocytes are usually recognizably larger. It is probable the gland cells are always present, but reduced to 2 or 3 cells, or to a single cell.

FIG. 14. Leg detail.

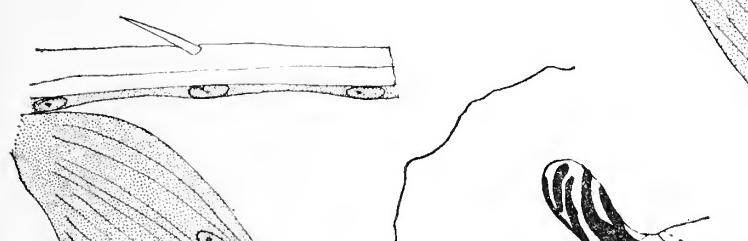
- A Gland at hindleg base *E. hamatum* queen with (below) detail of cell, ducts and openings through membrane joining body to leg and bristly outer surface.
 - B Part of wall of basal coxa of worker front leg, minute spines and nerves passing into them
 - C Section of apex of tarsus above comb, thick hypodermis, thick chitin wall with darkly stained cusps in endocuticle and fine bristles from cuticle
 - D Strigil with pectinate spur, comb and chitin walls
 - D_1 Section parallel to surface of comb, large canals (c.) to bases of coarse spines of comb and central nerve fiber (n.) passing into spines, and row of fine pores (p.)
 - D_2 Section beneath D_1 and at right angle to tarsus face
 - D_3 Detail section cut at right angle to long axis of tarsus, fine nerve (n.) through coarse canal (c.) into base of spine of comb and a group of fine pores (p.) through chitin wall
 - E t.s. metatarsus of *E. hamatum*, outer wall, hyopdermis (h.) coarse canal (c.) and fine pores (p.) and section metatarsal gland (gl.)
 - E_1 t.s. two successive lobes of gland
- Scale: A, B and D = 100 μ scale; others = 50 μ scale



A

A₁

A₂



B

C₂

C₁

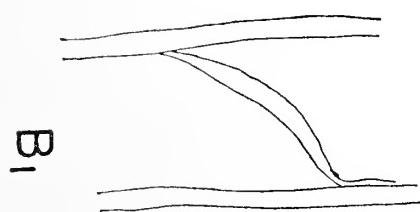
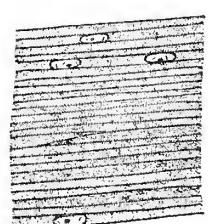
C

200 μ

m

m

D



B₁

The sclerotic wall of the legs of *Eciton* measures 35–50 μ . The hypodermal layer just beneath the wall varies greatly, not only in different areas, but also in the same area in different individuals. In one such area, in a queen, the hypodermis was uniformly only 2 μ thick; the corresponding area, in another queen, was 11–12 μ thick. Conspicuous in both workers and queens, was a thick hypodermal layer over the upper part of the thick membranes connecting the walls of the segments. Often these cells were 30 μ thick, and resembled a large gland.

The structure of the wall at some of the joints folds back extensively, forming narrow rings 200 μ or more in length, which in some cases overlap the wall of the succeeding segment, and in others extend under the wall of the preceding segment. In one case, where the femur joined the tibia, the external surface of the outer wall of the upper end of the tibia projected into a mass of slender spines 20–25 μ long. This area is nearly 250 μ long, and 80 μ broad. These spines are not articulated with the wall, but are rigid outgrowths therefrom. Numerous strongly curved micropores pass through the wall; but are not correlated with the spines. Beneath this area, the hypodermis consists of slender columnar cells up to 30 μ long and 4–5 μ broad. When the leg is straightened, this area is more or less concealed by an overlapping thin area of the preceding segment.

Similar to this is a small area at the upper end of the first tarsal segment. In this area, the numerous spines on the surface are about 4 μ long, tapering from a broad base to an exceedingly fine apex. Here, the wall has two sharply defined layers, each about 12 μ thick. The inner layer resembles the surface, having many finely pointed dark-staining regions extending upward from the inner surface. The hypodermis beneath the surface is formed of columnar cells 15–20 μ tall (Fig. 14, C).

FIG. 15. Chorodontal organ.

- A Worker minor
- A₁ and A₂ t.s.
- B Medium worker
- B₁ l.s. upper end major worker tibia to show position of organ
- C t.s. tibia and edge of femur (f.) to show organ (m = muscles)
- C₁ and C₂ Serial sections wall of leg near end of organ
- D l.s. nerve in tibia of major

The basal region of the coxa of each leg shows a small area from which several fine hairs stiffly project. These hairs, however, are typical tactile spines, $8-12\ \mu$ long, each having a fine nerve end extending through the wall and into the fine canal occurring in each hair (Fig. 14, B).

The chordotonal organ of these two species of *Eciton* is found in the upper end of the tibia of each of the six legs (Fig. 15, B₁, C). In any one form, it varies slightly in size and in the number of its component parts: naturally, it is larger in the queen than in the workers. Invariably, it is cylindrical to slightly fusiform, passing at an angle of 30–50° from the wall on one side of the tibia to that on the opposite side. Seen from the side, it starts as a mass flattened against the wall or as a cylindrical mass of compactly grouped fibres close to the wall for a length of $40\ \mu$ to $60\ \mu$ before it turns away and crosses to the opposite wall. Throughout its length, it is clearly recognized as a compact bundle of fibres $2-3\ \mu$ in diameter, enveloped in a thin membrane which is free of filaments. In these filaments, are several ellipsoid nuclei, $4-5\ \mu$ long and $2-3\ \mu$ in diameter. These occur in two groups usually near the ends of the filament mass (Fig. 15, A, B). This mass narrows abruptly at its distal end, where it lies closely against the hypodermal layer of cells. Occasionally, this distal end is bi- or even tri-furcate. The proximal end receives a slender nerve branch originating in the lower end of the femur.

The wall at the distal end of this organ shows two different conditions. In some cases, no modifications were found: in other cases, a conspicuous small pit was found in the wall near the slender tip of the chordotonal organ (Fig. 15, C₁, C₂). This pit had a maximum diameter between $7-9\ \mu$, and a length about one-half to two thirds the thickness of the wall where it occurred. Within this pit, several dark-staining (with haematoxylin) spirally curved structures occurred. In some cases, these were thickened areas on the surface of the wall; in others, they were free from the wall. There was no evidence of an opening from the pit to the outer surface of the wall of the tibia.

(Fig. 14, D). As in other ant species, the strigil has a pectinate spur, a bristle-fringed concavity opposing the spur and a large gland in the upper part of the tarsus.

The pectinate spur is a nearly solid chitin mass, the toothed

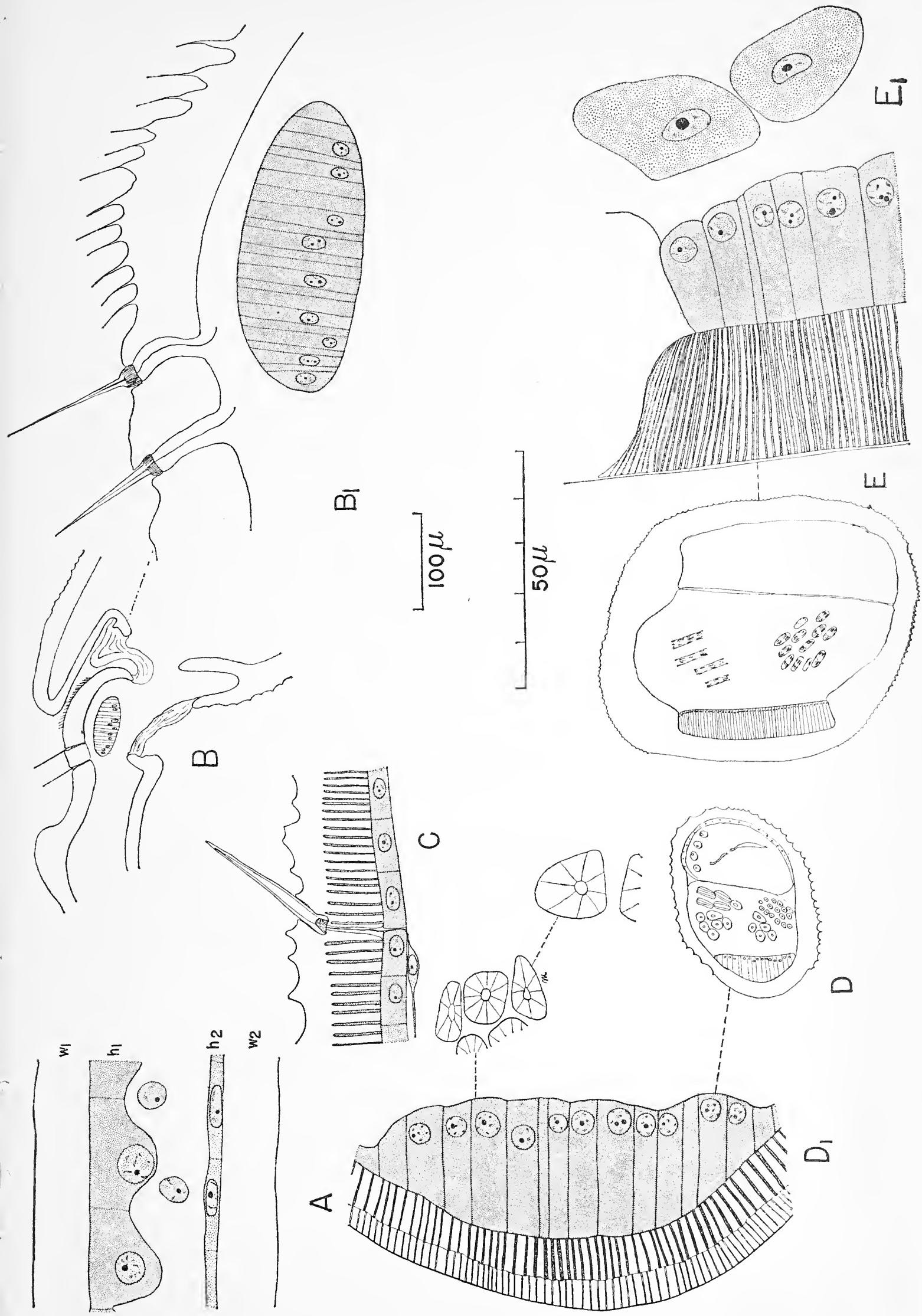
edge of which has a sigmoid outline. The base of this spur is a flattened disc around the edge of which the membrane from the lower end of the tibia to the upper end of the metatarsus is fastened.

The teeth of the concavity opposing the spur decrease uniformly from those of the upper end, 50–60 μ long, to those of the lower end 8–12 μ long varying more in individuals of differing sizes than in a group of individuals of uniform size. With the exception of the rigid basal and apical spines, spines in this row are articulated at the base and receive a fine nerve end which passes through a large pore in the wall, and into the basal end of the spine. The spines form a compact straight row: paralleling them about 3–4 μ distant, is an irregular narrow row of fine pores (Fig. 14, D₁, D₂). This irregular row may be as much as 12 μ wide in its greatest breadth, but near the end becomes a single row of coarse pores (Fig. 14, D₂). The fine pores are about 0.3 μ in diameter, the large ones about 1 μ .

These pores extend through the epicuticle; beneath that and through the remaining thickness of the wall, the latter becomes a spongy mass in which the very fine pores resemble lines rather than measurable pores (Fig. 14, D₃).

The basal end of the wall of the metatarsus is extremely irregular; one feature is a long thick incurved tooth projecting opposite the base of the pectinate spur. Along the edges of this tooth and around the rim of the wall of the segment, the membrane from the lower rim of the tibial wall is attached. When the leg is flexed, the tooth approaches the broad base of the pectinate spur which is turned away from the metatarsal surface. As the leg is straightened, the tooth moves away from the base of the spur, carrying the attached membrane with it. When the leg becomes straight or nearly so, the position of the membrane is such that the base of the spur is pulled upward into a shallow trough caused by the attachment of the membrane around the end of the tooth. The result is that the rigid pectinate spur is swung inward to press against the row of coarse spines opposing it on the tarsus.

In its simplest form, found in minor workers the metatarsal gland is an elongate kidney-shaped aggregate of cells. Penetrating to the center of this, is a mass of fine fibrous tissue. These are the fibres mentioned above as opening through the minute



pores forming an irregular row alongside the row of strong spines. The cells of this gland are irregular, and continuous with the hypodermal layer (Fig. 14, E)).

In larger forms and especially in the queens, this gland is much larger, filling a large part of the body of the metatarsus for approximately half its length. In this, as in all but the minor forms, the glandular cells form an elongated mass, shaped like a flounce, the edge (when viewed from the proper angle) forming an irregularly sinuous row of varying thickness. Beneath this sinuous mass, the cell layers partly surround an elongate fibrous mass extending the entire length of the gland. This fibrous mass sends similar tissue into the central part of the cellular flounces described above. The maximum width of the cellular mass may be 65–70 μ in major workers and soldiers and 80 μ in queens (Fig. 14, E₁).

Another specialized feature in the leg is an elongate mass of columnar cells, usually forming a layer continuous with the hypodermis (Fig. 16, D, E). Occasionally the continuity of the hypodermis with the columnar layer is limited to a small part of this mass of cells, which extends upward from the base of the tibia for one-third to one-half the length of the tibia. In rare examples, these cells extend nearly the entire length of the tibia, its upper end and the chordotonal organ appearing in the same transverse section. The actual location of this structure varies. The columnar cell mass is usually parallel to the thin septum that separates the tibia into two longitudinal chambers;

FIG. 16. Hypodermis modifications.

- A t.s. labrum, dorsal wall (w_1), thick hypodermis (h_1) and ventral wall (w_2) with thin hypodermis (h_2)
 - B l.s. apex of scape and base of flagellum
 - B₁ Detail similar area to show fine bristles on wall surface of flagellum base and thickened lenticular region of hypodermis
 - C l.s. tibia to show wall, hypodermis and nerve passing through wall into base of small tactile spine
 - D t.s. upper part of small worker tibia
 - D₁ Two distinct layers of wall, greatly thickened area of hypodermis (m = muscle fibers)
 - E t.s. tibia near upper end to show thick hypodermal structure sunk into depressed area of body wall
 - E₁ Detail similar thick hypodermal region plus two oenocytes
- Scale: B, D and E = 100 μ scale; others = 50 μ scale

but in rare cases, one edge of the mass adjoins the attachment of one edge of the septum to the wall of the tibia. Externally, the extent of this cell mass is vaguely indicated by the sparsity or absence of hairs from the wall surface over it, and by the unusually smooth wall surface. The shape of this modified area varies as much as does its extent. Often it has a rectangular outline with the long sides nearly straight, or bulging slightly, and with a rounded triangular apical region. Less frequently, it has a triangular outline, though the lateral sides do bulge slightly and the apex is often rounded. In one other aspect does this cell mass vary strikingly. This is shown in transverse sections of the leg (Fig. 16, D, E). In some legs, this cell mass is sunk into a depression in the wall of the tibia, to such an extent that the inner surface of the wall is almost continuous with the inner surface of the columnar cells. In such individuals continuity with the hypodermal layer may be lost. In these sunken cases, the apical region of the columnar cell is only a single cell wide. Frequently, the transition from hypodermis to columnar cells is gradual with transverse sections of the columnar layer having a biconvex outline. Finally, the modified layer is abruptly formed, continuous with the thin hypodermis, but with the columnar mass of cells projecting prominently into the lumen of the tibia. The wall over this layer of cells is variously modified, sometimes showing two sharply distinct layers with non-continuous micropores in each; in others, there are larger micropores extending through the entire thickness of the cuticle, but never through the distinct thin epicuticle (Fig. 14, D, E).

The dimensions of the several parts described here vary slightly (more, of course, if one sets the dimensions of the structures of minor workers against those of the queen): the columnar cells are from 30–35 μ tall; the overlaying chitin wall 16–18 μ thick; the epicuticle 0.6–08 μ . The maximum width of the modified layer varies from 160 μ to 190 μ in workers of the same size.

INTERNAL PARASITES

One more subject though not a matter of anatomy will be considered. During the course of this study, a question frequently asked was whether I observed parasites in *Eciton*. On the basis of material studied the answer is the *Eciton* is free from parasitic organisms. In the large number of specimens examined (including larvae, pupae, and adults of all

forms) only two individuals contained anything identifiable as an internal parasitic organism.

In a single large worker pupa, one of many collected May 28, 1946, the form of the mature worker was already clearly outlined, and all organs though recognizable within the wall were only vaguely indicated. The parasitic organism was found generally dispersed in the head, the thorax and the gaster. None occurred in the nerve centers, either brain or ganglia.

In some regions, it was found in small numbers, and widely separated; in other regions, the parasite was found in large

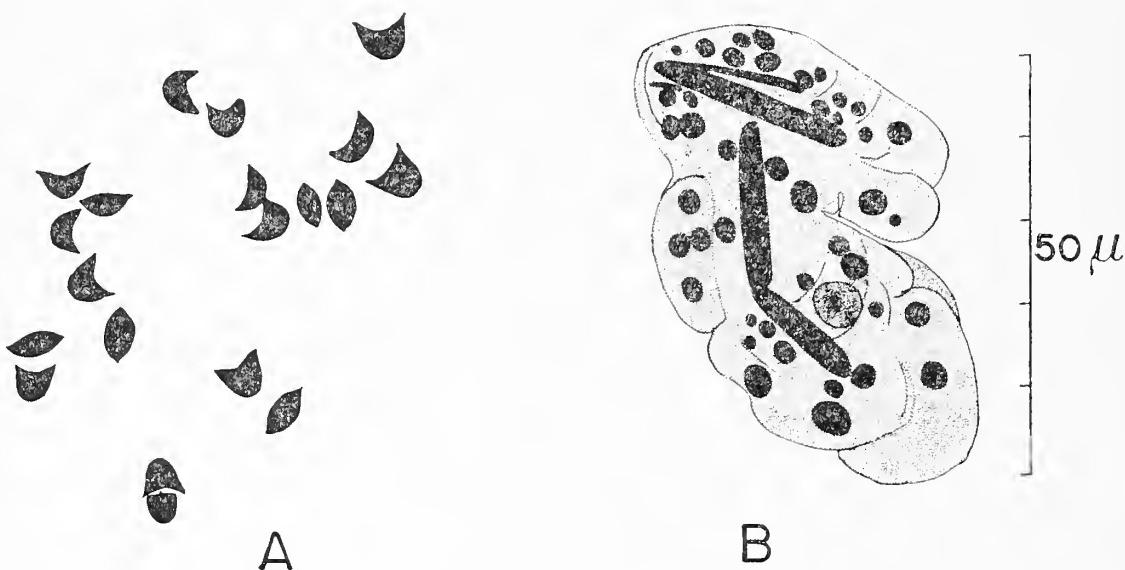


FIG. 17. Parasites found in *Eciton*.

- A Small parasitic organism found in late worker pupa
- B One of several small objects found in each of several of the aeration chambers of one queen only

numbers, densely aggregated. The parasite was a unicellular organism (Fig. 17, A), having the form of a coarse crescent with bluntly pointed ends. Size varied from 5 by $3\text{ }\mu$ to 4.8 by $4\text{ }\mu$ to a conspicuously small one measuring 3.5 by $2.5\text{ }\mu$. The thickness was 2.2 – $2.5\text{ }\mu$. No other specimen from this collection or any other collection, contained a single parasite.

The second object is a very different one. Looking at the small pores called "aeration pores" above, has led some to ask whether foreign organisms (that is, parasites or whatever) passed through these pores and eventually into the large chambers to which the tube led. In only one mature queen of *E. hamatum*, have I observed foreign bodies in "aeration chambers" (Fig. 17, B). They vary in size (a small one measuring 58 by $33\text{ }\mu$; a large one 70 by $24\text{ }\mu$) ; and in shape. All hold the haematoxylin stain,

the black color usually concealing details. Occasional specimens show the presence of what may be a few nuclei 4–6 μ in diameter. They are found in large irregular cells, much like stomach cells in shape and association. They also contain elongate structures that may be masses of muscle fibres; and many dark round globules which could be a substance similar to the fat-globules present in adipocytes. Some are obviously formed into segments vaguely suggesting head, thorax and abdomen, the first bent down more or less closely against the second. There is no sign of appendages.

Whether these be organisms or merely some inorganic fluid condensed after passing into the bladder, must remain unanswered here. It does indicate that material can upon rare occasions pass into the body through these pores.

No other foreign object or organism was seen in any specimen in this study.

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AN ANNOTATED LIST OF THE LYCAENIDAE (LEPIDOPTERA: RHOPALOCERA) OF THE WESTERN HEMISPHERE

BY WILLIAM PHILLIPS COMSTOCK AND EDGAR IRVING HUNTINGTON

sternitzkyi Field, William D., *Lycaena dorcus* race *florus*

Type Locality: Broadwater County, Montana, July 30, 1930.

Location of Type: W. D. Field Collection, Lawrence, Kansas. (United States National Museum?)

Original Description: 1936, Jour. Ent. Zool. Pomona College, vol. 28, p. 26 (Claremont, Calif.).

Additional Reference: McDunnough, J. H., 1938, Check list, pt. 1, p. 26, no. 432 (Los Angeles, Calif.). (Places the name as *Lycaena heliooides florus* form ♀ *sternitzkyi* Field.)

stictos Draudt, Max, *Thecla* (not Druce) Misspelling of *stiktos* Druce

Type Locality:

Location of Type:

Original Description: 1919 (December), The Macrolepidoptera of the World, vol. 5, p. 764, pl. 151-a (Stuttgart).

stigmatus Druce, Hamilton H., *Thecla*

Type Locality: Interior of Colombia.

Location of Type: Druce Collection (♂).

Original Description: 1890, Ent. Mo. Mag., Series 2, vol. 1, p. 152 (London).

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 584, pl. 34, fig. 2 ♂ (London).

stiktos Druce, Hamilton H., *Thecla*

Type Locality: Interior of Colombia.

Location of Type: Druce Collection (♂).

Original Description: 1890, Ent. Mo. Mag., Series 2, vol. 1, p. 151 (London).

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 584, pl. 34, fig. 1 ♂ (type) (London).

Synonyms: *stictos* Draudt.

stilbia Hewitson, W. C., *Thecla*

Type Locality:

Location of Type: British Museum (Natural History).

Original Description: 1867, Illus. of Diurnal Lepidoptera, vol. 1, p. 107, vol. 2, pl. 39, fig. 127 ♂ (London).

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 603 (London). (Says that specimens from Espiritu Santo, Brazil agree with the type in the British Museum.)

strenua Hewitson, W. C., *Thecla*

Type Locality: Brazil.

Location of Type: British Museum (Natural History).

Original Description: 1877 (January), Illus. of Diurnal Lepidoptera, vol. 1, p. 207, pl. 82, figs. 689, 690 ♀ (London).

strephon Fabricius, Johann Christian, *Papilio*

Type Locality: "In India Orientali."

Location of Type: Banksian Collection, British Museum.

Original Description: 1775, *Systema Entomologiae*, p. 522 (Flensburgi).

Additional References: Butler, A. G., 1869, Catalogue of Dinural Lepidoptera Described by Fabricius in the Collection of the British Museum, p. 186 (London). Lathy, P. I., 1926, Ann. Mag. Nat. Hist., Series 9, vol. 17, p. 44 (London).

Synonyms: *sicheus* Cramer, *sichaeus* Kirby syn.

Subspecies: *occidentalis* Lathy.

striata Edwards, William H., *Lycaena*

Type Locality: San Antonio, Texas.

Location of Type:

Original Description: 1877 (November), Field and Forest, vol. 3, p. 88 (Washington, D. C.).

Additional Reference: Comstock, W. P. and E. I. Huntington, 1943 (December), Ann. New York Acad. Sci., vol. 45, p. 90 (New York). (Make *striata* a subspecies of *cassius* Cramer.)

strigosa Harris, Thaddeus William, *Thecla*

Type Locality: Blue Hill, Massachusetts, August 1.

Location of Type:

Original Description: 1862 (February), in Morris, Synopsis of the Lepidoptera of North America, Smithsonian Misc. Coll., p. 101 (Washington, D. C.).

Additional References: Harris, T. W., 1862, A Treatise on some of the insects of New England which are injurious to vegetation (Flint Edition), p. 276 (Boston, Mass.). Michener, C. D. and C. F. dos Passos, 1942 (November), Amer. Mus. Novitates, no. 1210, p. 3, (New York, N. Y.).

Synonyms: *pruina* Scudder.

Subspecies: *aliparops* Michener and dos Passos, *fletcheri* Michener and dos Passos, *liparops* Fletcher syn.

strophius Godart, Jean B., *Polyommatus*

Type Locality: Brazil.

Location of Type:

Original Description: 1821, Encyclopédie Méthodique, vol. 9, p. 632 (Paris).

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 568 (London). (Did not recognize the species.)

suada Hewitson, W. C., *Thecla*

Type Locality; Bolivia.

Location of Type: British Museum (Natural History).

Original Description: 1877 (January), Illus. of Diurnal Lepidoptera, vol. 1, p. 207, vol. 2, pl. 82, figs. 691, 692 ♂ (London). (Hewitson makes *suada* a synonym of *ceromia* Hewitson which we believe to be incorrect.)

Additional Reference: Druce, H. H., 1907 (June), Proc. Zool. Soc. London, p. 264 (London). (Accepts Hewitson's synonymy and says "the types are more alike than his figures.")

suasa Boisduval, Jean A., *Lycaena*

Type Locality: Mountains of eastern California.

Location of Type: United States National Museum?

Original Description: 1869, Ann. Soc. Ent. Belgique, vol. 12, p. 51 (Bruxelles).

Additional Reference: Oberthür, Charles, 1913 (October), Etudes de Lépidoptérologie Comparée, fasc. 9, pt. 1, p. 43, p. 240, fig. 2080 ♂ (Rennes).

Note: *Suasa* is considered to be a synonym of *fuliginosa* Edwards.

subarcticus Chermock, F. H., *Plebeius scudder*

Type Locality: Fairchild Point, Great Slave Lake, N. W. T., Canada, July 22, 1927.

Location of Type: Author's Collection.

Original Description: 1944 (November), Can. Ent., vol. 76, p. 213 (Guelph, Ont.).

subflorens Schaus, William, *Thecla*

Type Locality: Poas, Costa Rica.

Location of Type:

Original Description: 1913 (September), Proc. Zool. Soc. London, p. 353, pl. 52, fig. 9 ♂ (London).

sublivens Nabokov, V., *Lycaeides argyrogномон*

Type Locality: Telluride, San Miguel Mountains, S. W. Colorado, 10,000–12,000 ft., July 28–30, 1902.

Location of Type: Museum of Comparative Zoology.

Original Description: 1949 (February), Bull. Mus. Comp. Zool., vol. 101, no. 4, p. 513, pl. 1, fig. 27, pl. 5, fig. 65 (Cambridge, Mass.).

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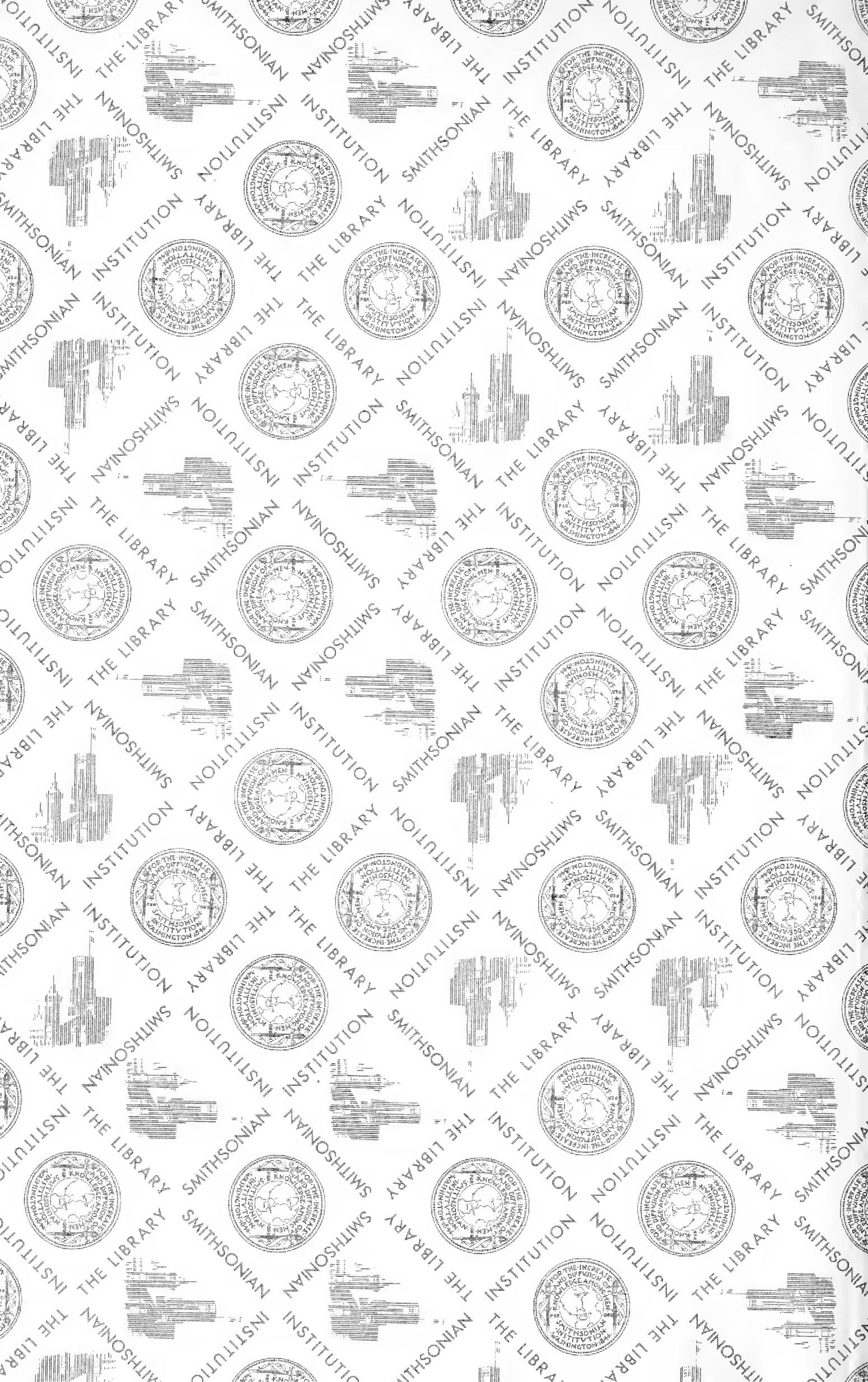
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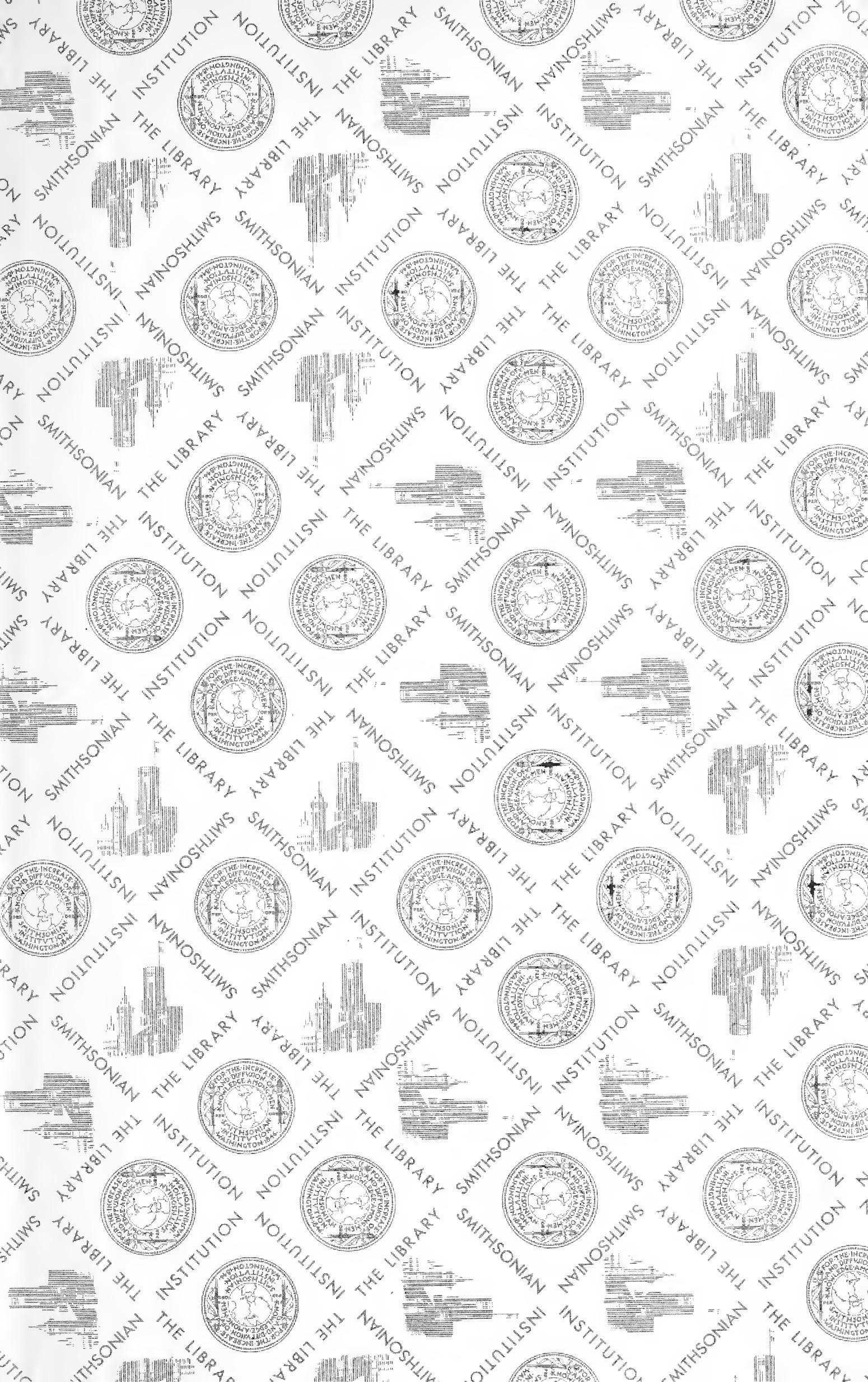
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